NAVAL POSTGRADUATE SCHOOL

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THESIS

A MOVING TARGET FIELD EXPERIMENT TO DETERMINE THE EFFECTIVENESS OF CIRCULAR BRACKETING SIGHTS ON THE M16A1 RIFLE

by

George Alexander Fisher, Jr.
and
Frank Russell McLeskey

Thesis Advisor: J.K. Arima

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George Alexander Fisher, Jr.
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A Moving Target Field Experiment to Determine
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on the M16A1 Rifle

by

George Alexander Fisher, Jr.
Captain, United States Army
B.S., United States Military Academy, 1964

and

Frank Russell McLeskey
Captain, United States Army
B.E.E., Auburn University, 1962

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March 1972

Authors George A. Fisher, Jr.

Frank R. McLeskey

Approved by: James K. Arima
Thesis Advisor

Chairman, Department of Operations Research
and Administrative Sciences

Academic Dean

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A field experiment was conducted to determine whether a circular bracketing sight mounted on a standard M16A1 rifle could enhance the effectiveness of the weapon in a short-range, quick-fire environment against a moving target. Circular bracket sights of 1.32 and 2.64 ins. in diameter were used. Human silhouette targets appeared moving along a track at 6 mph. at distances of 25 and 50 yds. and remained exposed for approximately 2.5 secs. Subjects were infantrymen who engaged the target (single-shot) with each sight and at each direction of target movement (right-left) and range. An unmodified M16A1 sight was tested by the same subjects for comparison using standard quick-fire techniques. Results showed approximately 150% increase in the single-shot hit probability using either circular bracketing sight. The advantage of the bracketing sights was especially pronounced at the 50-yd. range. Subjects preferred the smaller bracketing sight.

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ACKNOWLEDGEMENT

The authors wish to express their appreciation to the U.S. Army Combat Developments Command Experimentation Command, Fort Ord, California, for the use of its range facilities and for generous and outstanding support throughout the experiment.

I. BRIEF

A. PROBLEM

To improve the effectiveness (hit capability) of the infantry rifleman in short-range, quick-reaction situations against moving targets.

B. PROCEDURE

Twelve infantry soldiers (subjects) with previous quick-fire experience were trained in the use of two circular bracketing sights differing only in size. Each of these sights was mounted on the front sight post of a M16A1 rifle.

Testing was conducted on a moving target rifle range under normal daylight conditions. The range was located in sparsely vegetated, slightly hilly terrain. Two firing positions, for right and left directions of target movement, were established at each of two ranges, 25 and 50 yds. Testing consisted of determining the capability of the subjects to hit a standard silhouette target moving laterally at a constant speed of 6 mph. The target was exposed for 2.5 secs. for each single-shot engagement. Three methods of firing were utilized: standard Army quick-fire, bracket aiming with a 2.64 inch diameter (hereafter called "large") circular sight, and bracket aiming with a 1.32 inch diameter (hereafter called "small") circular sight. All firing was done from the standing position and each subject fired a total of 60 test rounds.

The performance of the subjects was analyzed to determine significant differences in hit capability between sight configurations, range distances, and movement directions. In addition, formal post-test questioning of the subjects was analyzed to determine an overall subjects' profile, comments concerning the experiment, and preferences for the three sight configurations.

C. FINDINGS

Employment of each of the circular bracketing sights resulted in a significant increase in the number of targets hit. The small and large circular sights achieved 149% and 159% improvement, respectively, in overall hit capability over the standard quick-fire procedure. The improvement was more pronounced at 50 yds. The subjects also agreed strongly on their preferences for the circular sights over the unmodified version.

D. UTILIZATION OF FINDINGS

The development of an optimized front aperture sight for the M16A1 rifle and its employment should materially increase the hit capability of the individual rifleman in short-range, quick-reaction, combat engagements. The training of soldiers in the use of the bracket aiming procedure associated with the circular sight configuration could be incorporated into present basic and advanced marksmanship programs. Training and familiarization firing can be accomplished in two to three hours.

In addition, the bracketing concept may have fruitful extensions to night engagements, aerial targets, machinegun engagements (particularly for helicopter door gunners), and to basic target acquisition training.

II. BACKGROUND

A. CONCEPT DEVELOPMENT

Bringing to bear effective small arms fire has always been of the highest priority in crucial close combat engagements with the enemy. Many proposals have been suggested to meet the requirement to increase the hit capability of the individual rifleman. The target acquisition and sighting devices areas have provided their share of such proposals. As targets and combat conditions change, difficult problems can be identified in these areas.

The near impossibility of getting hits against sudden (moving or fleeting) targets at even close ranges has led the Army to train its riflemen in the use of quick-fire techniques. Present Army doctrine stresses the use of pointed, automatic fire to gain superiority in short-range, quick-reaction engagements. As a result, the number of rounds fired in combat per casualty has been estimated to be at least several tens of thousands. Additionally, there exists almost no opportunity for using the aimed fire potential of the M16A1 rifle in combat (Vietnam). Most targets presented to the rifleman have not been visible, or if visible have been moving, or if visible and stationary have been so pressing a threat that the rifleman could not afford the time to aim using the conventional two component (front and rear) sighting system of the M16A1.

The Small Arms Advisory Committee of The Advanced Projects Research Agency of the Office of The Secretary of Defense has proposed the concept of a new short-range battle sight in which the rear sight is used as a post and the front sight is a large aperture. The basis of this concept

was that this type of sighting system would assist the rifleman in acquiring and maintaining selected aiming points under combat conditions.

B. PREVIOUS RESEARCH

Kemple and McKinney [3] proposed a combat battle sight which employed the unmodified rear sight of the M16A1 as a post and a circular bracketing sight framing the normal front sight of the rifle. Circular brackets with apertures of 2.64 and 1.32 ins. in diameter, respectively, were fabricated from aluminum and mounted on M16A1 rifles. A field experiment was conducted using infantry soldiers as subjects who fired a test course against stationary targets exposed for 1.6 secs. at ranges of 25 and 50 yds. It was determined that the use of the small circular sight resulted in a 23% increase in hits over the unmodified and the large circular sights.

C. CURRENT RESEARCH EFFORT

Although moving ground targets represent a significant number of all combat targets, present Army basic and advanced rifle marksmanship programs have been void of any training in this area. The significance of the findings of Kemple and McKinney [3] suggested that further research on the proposed battle sight in a moving ground target environment would be fruitful. The ability of the rifleman to make a quick integrated picture of the weapon and the moving target would be critical to hit capability. It was proposed that the circular bracketing sight would enable the rifleman to make a more accurate sight picture than normal by providing him important but unobstrusive reference points. Consequently, the current research was undertaken to provide information to assist in answering the following question: Would the circular bracketing sight system improve the rifleman's hit capability against moving ground targets?

III. PROCEDURE

The sighting devices used in this field experiment were the unmodified M16A1 sights, and the two different sized circular bracketing sights. Figures 1 and 2 depict the configurations and the component parts of the bracketing sights.

The moving target range, utilized for testing the sight configurations, was located at Hunter-Liggett Military Reservation and was situated on gradually sloping downhill terrain, only lightly cluttered with trees and brush. All testing was conducted under normal daylight conditions. The range system's cart with silhouette target traversed a lateral path over 150 ft. in track length. This track was nearly perpendicular to four firing points established two each at 25 and 50 yd. ranges. The track and cart as well as a portion of the target were concealed by a four foot high dirt berm. An "operations" bunker 200 yds from the track contained the motive power for the cart system. A Flender-Polydrive with attaching cables to the cart was the basis of the power system. The target was presented for any single engagement moving in a right or left direction along the track at 6 mph. Exposure time of the target to the firer was 2.5 secs.

The experiment was conducted using 6 different subjects (infantry soldiers) on two consecutive days of testing. Each day's experimentation was identical in format. When the subjects arrived at the range, they were given an orientation which included the background and purpose of the experiment as well as a demonstration showing the range configuration and operation. Following this orientation, refresher training in the Army's standard quick-fire technique was conducted along with special

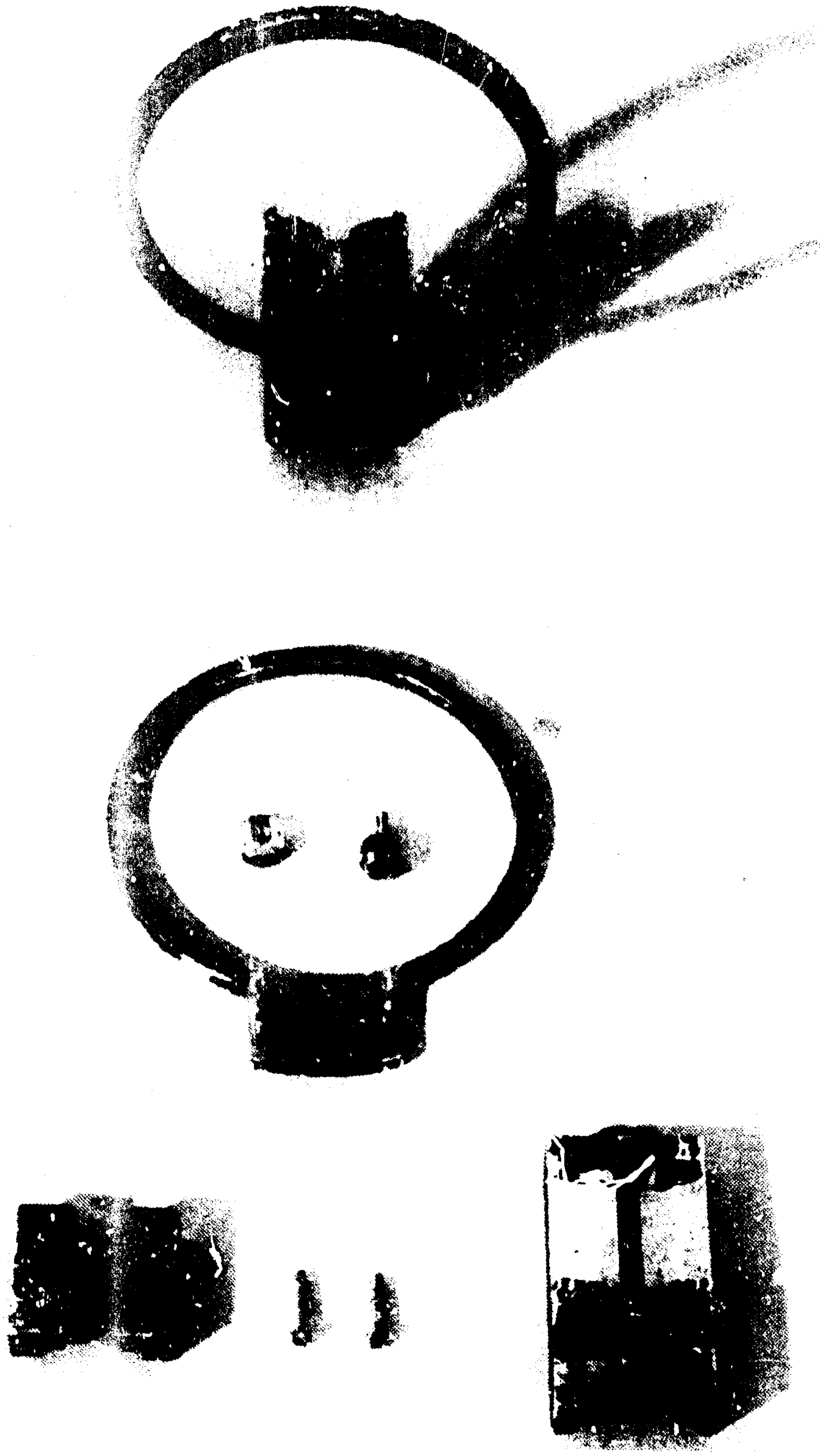


FIGURE 7. Component Parts of Large Bracketing Sight.

FIGURE 2. Component Parts of Small Bracketing Sight.

training in the use of the bracket aiming procedure for the circular sights. This training was concluded with live practice firing from the 25 yd. firing points against a stationary target. The purpose of this firing was to ensure that each subject attained the proper body-weapon-target alignment. All subjects then underwent a formal familiarization course of firing using the three sight configurations. When this familiarization firing had been completed, the subjects were given a short break after which actual test firing commenced.

A subject was assigned randomly to either of the firing points (left or right) at, for example, the 25 yd. range. Thus with two subjects on the firing line, a particular sight configuration was then randomly assigned to each. The subjects separately engaged the target in a single-shot mode as it moved in their particular direction. When 5 rounds had been fired by a subject with a particular sight configuration, he was relieved and another subject was then randomly assigned to fire. Data, collected at the firing line, consisted of the number of hits (out of five) achieved by a particular subject with a given sight configuration from a specific firing point. Testing was completed when all subjects had fired each of the three sight configurations at both left and right firing points at the two ranges.

When all test firing had been completed, a questionnaire was given to each of the subjects eliciting personal data and comments concerning the experiment.

IV. RESULTS

The data were analyzed to determine if any significant differences existed between the standard quick-fire technique, the small circular bracketing sight, and the large circular bracketing sight in short-range, moving target engagements using the M16A1 rifle in daylight conditions. Additionally, it was desired to determine if any significance which did occur was consistent over changes in range and direction of target motion. The overall results are presented in Table II by sight configuration and range.

A. SIGHT DIFFERENCES

The small and large bracketing sights were found to be significantly better than the quick-fire technique (Table VIII). The data combined over ranges from Table II shows 25.4% hits using the unmodified sight, while the small and large bracketing sights achieved 63.3% and 65.8% hits, respectively. No significant difference could be claimed between the small and large circular sights. The small and large circular sights produced an overall increase in hits of 149% and 159%, respectively, over the unmodified sight (Table III). No implication can be made from these results as to what the optimum bracket size might be.

B. INTERACTIONS

No significant interactions were found between combinations of test variables (Table VIII). This indicates that the results cited above with respect to hit probabilities are consistent over the ranges (25 and 50 yds.) and directions of motion (90 degrees left and right) tested.

C. RANGE DIFFERENCES

The 25-yd. range was found to be significantly better (in hit production) than the 50-yd. range (Table VIII). Targets were hit 67.7% of the time from 25 yds. and 36.9% from the 50 yd. range. It was also found that, at the 50 yd. range, the advantage in number of hits for the circular sights was significantly increased over the advantage they had enjoyed at 25 yds. The percentage improvement of the small and large circles over the unmodified sights advanced from 115% and 118%, respectively, at 25 yds. to 244% and 275%, respectively, at 50 yds. (Table IV).

D. DIFFERENCES IN DIRECTION OF TARGET MOTION

No significant difference was found in the number of hits achieved on a left-moving target as compared to a right-moving target (Table VIII).

E. QUESTIONNAIRE RESULTS

Results of the subject questionnaire (Table I) show that a definite preference emerged for the small circular bracketing sight. Nine subjects chose the small circle as "best" while three chose the large circle and none chose the unmodified (Table XII).

TABLE I. COMPARISON OF SIGHT PREFERENCE AND SUBJECT PERFORMANCE

RANK	SUBJECTS' PREFERENCE	SUBJECTS' HIT PERFORMANCE
1	small circle	large circle
2	large circle	small circle
3	unmodified	unmodified

TABLE II. PERCENT HITS BY SIGHT AND RANGE

SIGHT	RANGE		
	25 YARDS	50 YARDS	COMBINED
unmodified	37.5	13.3	35.4
small	80.8	45.8	63.3
large	81.7	50.0	65.8
all sights	67.7	36.4	51.5

TABLE III. SUMMARY OF EFFECTIVENESS ANALYSIS

VARIABLE	LEVEL	NO. HITS	% HITS	PERCENT INCREASE IN EFFECTIVENESS
Sight	unmod	61	25.4 %	
	small	152	63.3 %	149% over unmod
	large	158	65.8 %	159% over unmod
Distance	25 yds.	240	67.7 %	83.2% over 50 yds.
	50 yds.	131	36.4 %	
Direction	left	184	51.1 %	
	right	187	52.0 %	
TOTAL		371	51.5 %	

note: 720 rounds fired

TABLE IV. PERCENT IMPROVEMENT OF CIRCULAR SIGHTS OVER UNMODIFIED SIGHT BY RANGE

	RANGE		
SIGHT CONFIGURATION	25 yds.	50 yds.	combined
small circle	115.0 %	244.0 %	149.0 %
large circle	118.0 %	275.0 %	159.0 %

V. CONCLUSIONS

A circular bracketing front sight modification to the M16A1 rifle could drastically improve the percentage of hits against a moving ground target in short-range, quick-reaction engagements. The modification was preferred to quick-fire techniques and tended to increase the subjects' confidence by increasing their "success" in firing. In such a capacity, it should be a useful training device.

The success of quick-fire techniques in the test deteriorated rapidly as the range was increased. The bracketing aid's advantage apparently is increased as the range is increased.

Results indicated that a rifleman with sufficient practice could effectively engage a target moving left equally as well as one moving right.

VI. RECOMMENDATIONS

A. OPTIMAL SIZE AND SHAPE

Although the two bracketing sights tested proved far superior to the quick-fire technique, there was no indication that the size or even the shape of the brackets were optimal. Various shapes such as triangles or rectangles and various sizes of bracket should be investigated to attempt to establish an optimal configuration for various types of engagements.

B. TYPE OF ENGAGEMENT

There has long existed a need for improved sight systems for night engagements. An optimal bracketing sight with radioactive paint could be tested under varying conditions of reduced visibility to evaluate its effectiveness in improving night engagement results.

Additional target speeds should be tested as there are indications that optimal sight size may vary with the speed of the target.

It has been suspected that, in a quick-reaction environment, it would be easier to place a moving target inside a bracket and keep it there than it would be to keep a single post aligned with the moving target as in the present mode of sighting. Tests could be conducted to establish this point. Significant results could then lead to tests using the bracketing technique for automatic fire engagements and for engagements of aerial targets. A minimal amount of exploratory firing in this present research indicated that the bracketing sight could be held on target relatively easily with the weapon in the automatic mode.

C. MACHINEGUNS

The bracketing sight tended to cut down the area engaged by the subject. With emphasis on an accurate volume of fire with automatic weapons, it

might be found that a bracketing device could reduce the disperion of automatic fire. The bracketing sight might especially be tested for helicopter door gunners who normally have problems quickly acquiring a target and confining their fire to a constrained target area.

D. TRAINING

The acquisition advantages indicated by the test results suggest that the bracketing type sight might be successfully employed as a target acquisition aid in basic and advanced rifle marksmanship training programs.

E. PERIPHERAL VISION

It has been proposed that a soldier hesitates to use his standard sights in combat especially in a quick-reaction situation because the present sighting system drastically reduces his peripheral vision and thus his awareness of what is happening around him. Tests could be run to determine if the bracketing type sight permits better peripheral vision by using the rear sight as a post and eliminating the requirement that the rifleman look through a small rear aperture. If such were the case, the bracketing type sight would encourage the use of sights and probably reduce the rounds-per-casualty ratio.

VII. TECHNICAL SUPPLEMENT

A. PERSONNEL AND EQUIPMENT

1. Subjects

Twelve enlisted men from "F" Company, Experimentation Battalion, Experimentation Brigade, U. S. Army Combat Developments Command Experimentation Command (CDCEC), Ft. Ord, California served as subjects for the experiment. Each subject was a righthanded firer, previously trained in quick-fire techniques, and possessed an Infantry (11B) Military Occupational Specialty. No other special selection criteria were utilized.

2. Weapons and Ammunition

Eight U. S. Army M16A1 rifles were provided by CDCEC for use in the experiment. Two of the weapons were modified by attaching small circular brackets to the front sight posts. Two others were modified with large circular brackets and two were selected as the unmodified configuration. The remaining weapons were on hand in case of malfunction of any of the others. However, the "spare" weapons were not required during any of the testing. It should also be noted that rifle slings were not utilized during any practice, familiarization or test firing.

Ammunition was standard 5.56 mm ball and contained no tracers. A total of 720 rounds was expended during the actual test firing.

3. Sight Configurations

Three sight configurations were tested: The unmodified M16A1 sighting system, the large circular sight, and the small circular bracket. Previous research [3] indicated the circular bracket to be a prime candidate for testing the acquisition process against moving ground targets. This

research described the development of the circular brackets as feasible front sights. The small bracket when attached to the front post would encompass a breadth of 60 ins. or 3 average men at a distance of 25 yds. A diameter of 1.32 ins. was thus derived for this circular bracket. Similarly, the large bracket encompassed a breadth of 120 ins. or 6 average men at 25 yds. This yielded a diameter of 2.64 ins. Figures 3 to 8 show the rifleman's body-weapon alignment and sight picture for the three configurations.

4. Range Equipment and Operation

The moving target range used for this experiment was part of CDCEC's facilities at Hunter-Liggett Military Reservation, Jolon, California. For testing the three different sight configurations, the moving target system included over 150 feet of aluminum track, a wheeled cart with target, a Flender-Polydrive, a cart position display panel and target control electronics. One modified M31A1 target mechanism and a standard polyethylene kneeling [E-type] instrumented target were mounted on the cart. When raised and viewed from the established firing positions, the target presented a front view. Figure 9 presents the target exposure area and Figures 10 and 11 show the target as seen by the firer at the 25 and 50 yd. ranges. Two 12-volt storage batteries were also mounted on the cart to provide power to raise and lower the target. An electronics package mounted on the cart provided remote control operation of the target mechanism. Figures 12 and 13 illustrate the track and cart components and Figures 14 and 15 show the target in the "up" and "down" positions.

Motive power for the system was provided by the Flender-Polydrive which consisted of an industrial Volkswagen engine driving a continuously variable hydraulic transmission whose output was manually clutched to two

FIGURE 3. Front View of Soldier with Unmodified Sight in Quick Fire Position

FIGURE 4. Side View of Soldier with Unmodified Sight in Quick Fire Position

FIGURE 5. Front View of Soldier with Large Circular Sight in Firing Position

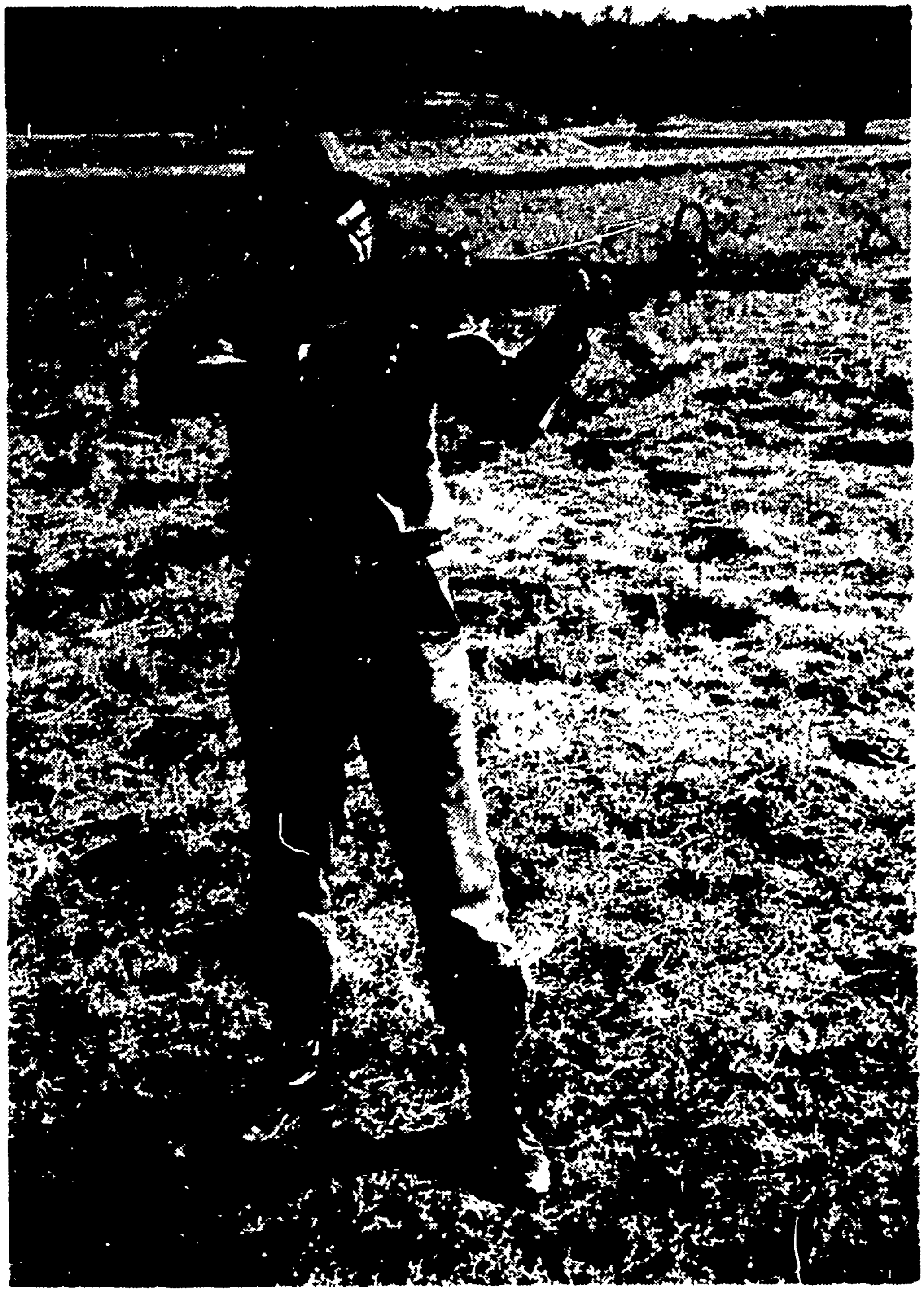


FIGURE 6. Side View of Soldier with Large Circular Sight in Firing Position

FIGURE 7. Front View of Soldier with Small Circular Sight in Firing Position

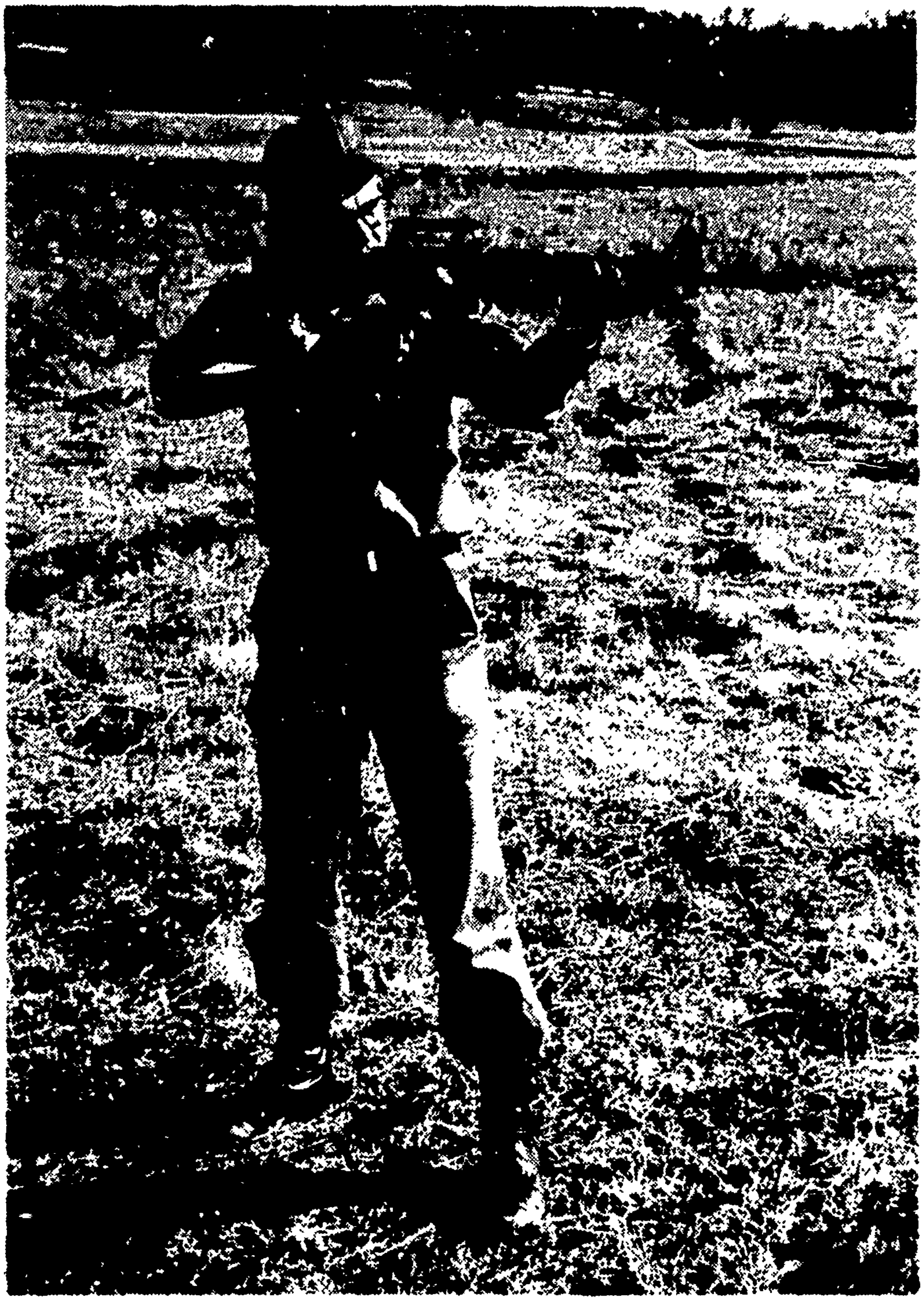
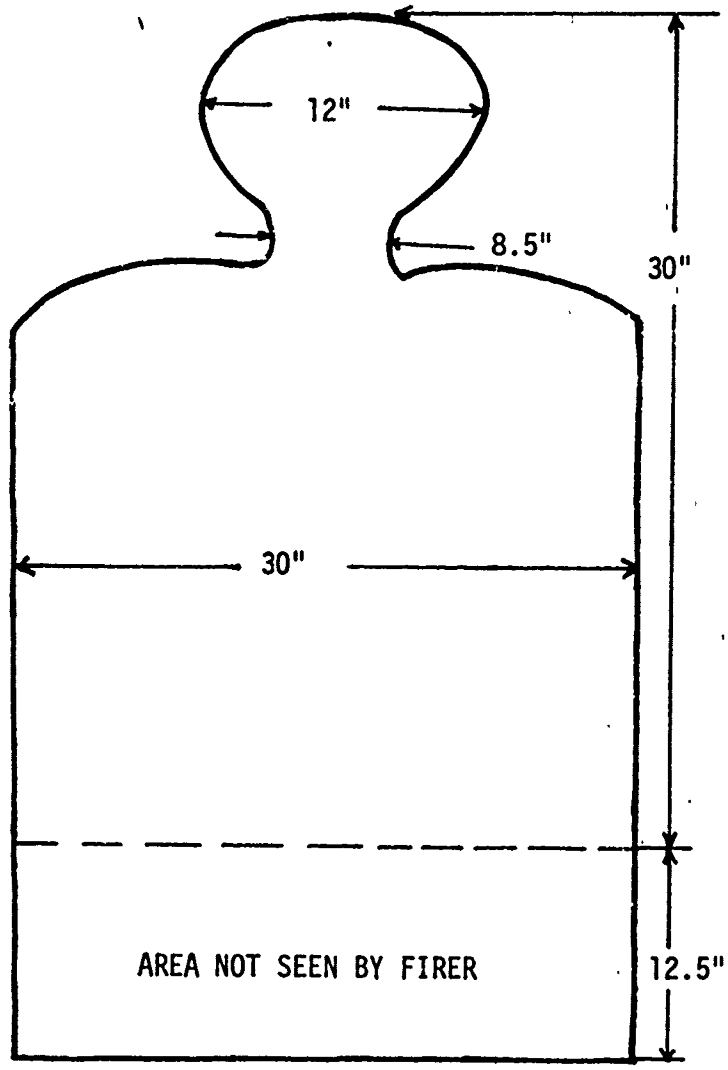


FIGURE 8. Side View of Soldier with Small Circular Sight in Firing Position



NOTE: Dimensions approximate and not to scale.

FIGURE 9. Dimensional Sketch of Silhouette Target

FIGURE 10. Target as Viewed from 25 Yard Range by the Firer

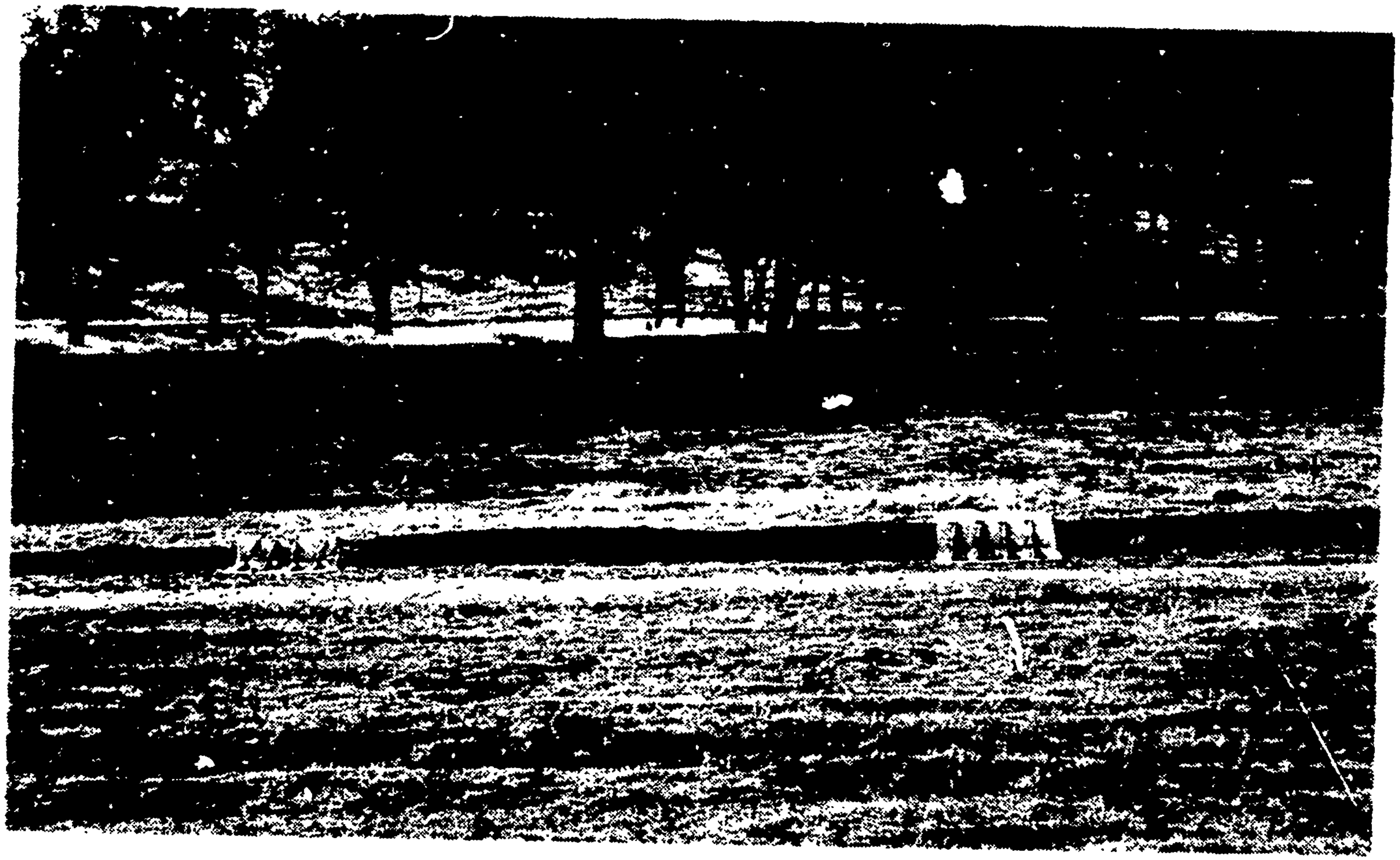


FIGURE 11. Target as Viewed from the 50 Yard Range by the Firer

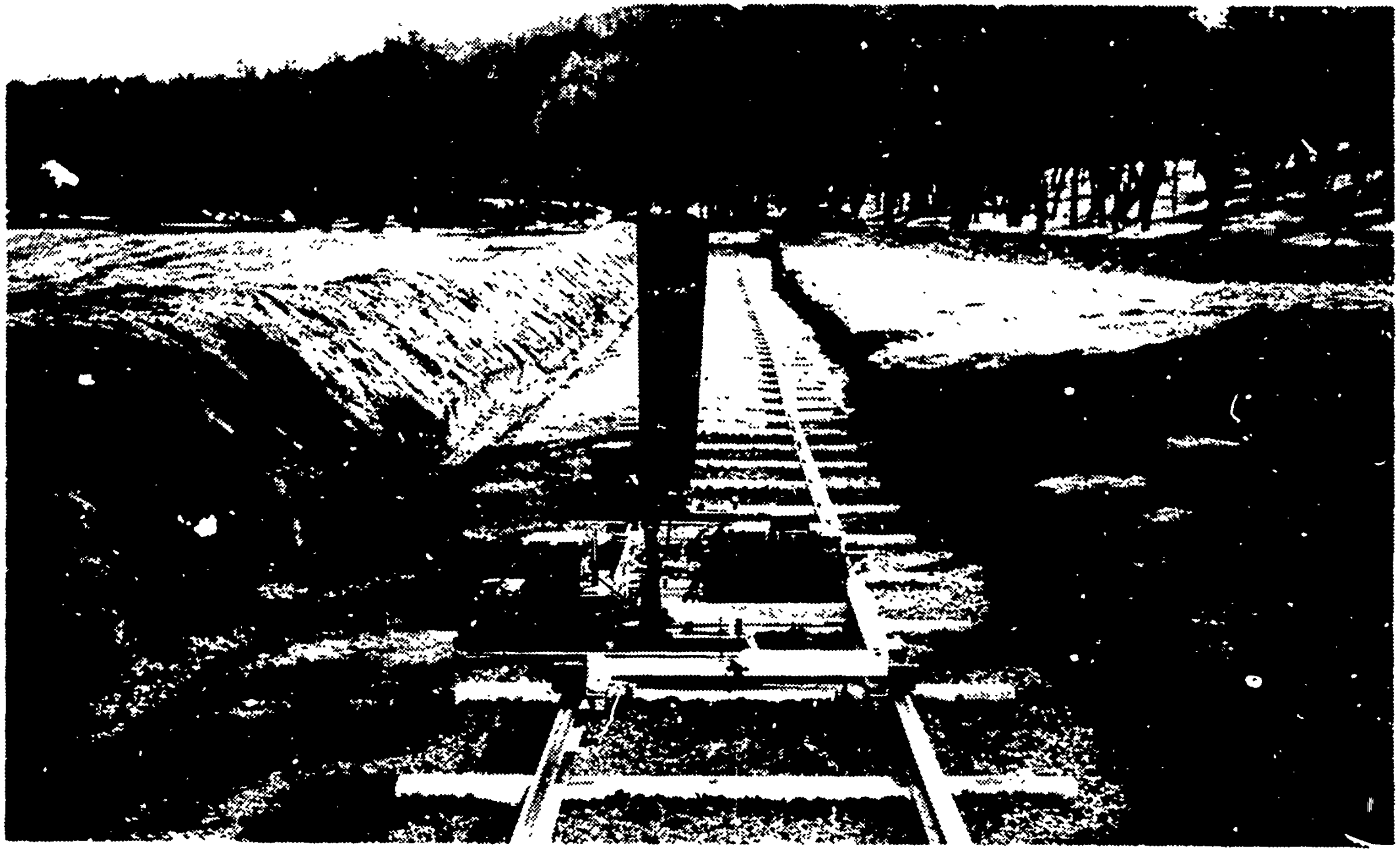


FIGURE 12. View of Track and Target Cart

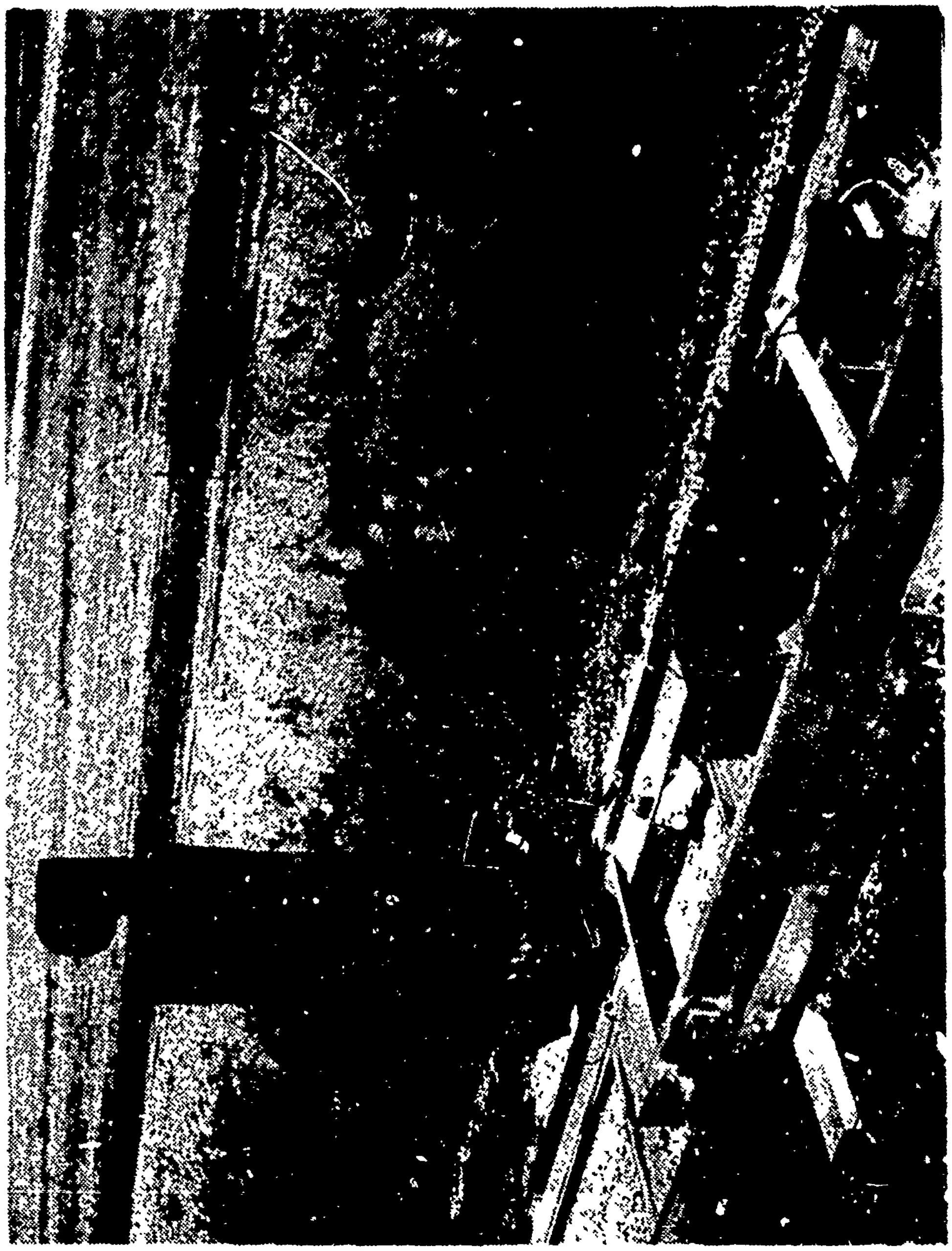


FIGURE 13. Closeup View of Target Cart Components

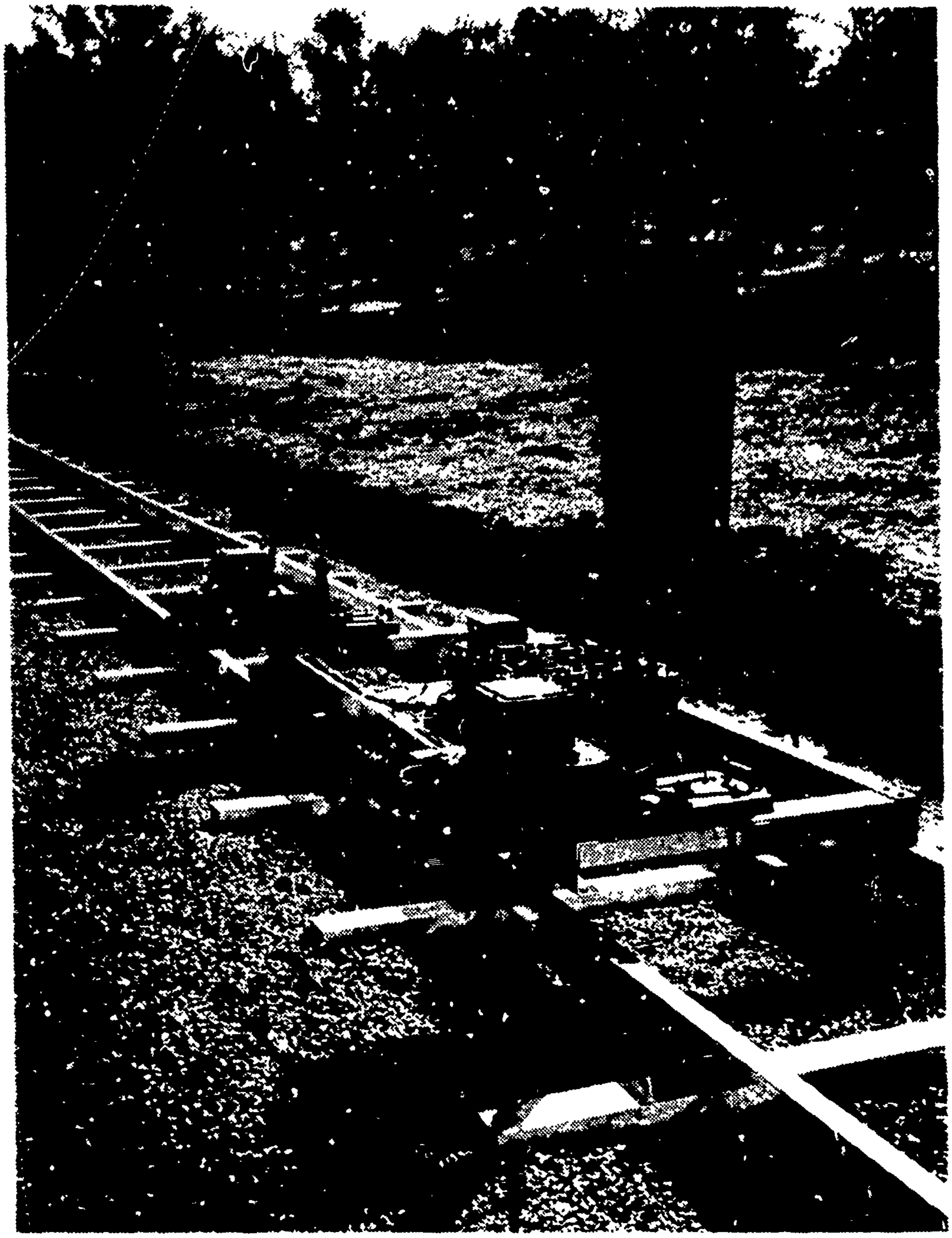


FIGURE 14. View of Target in Raised Position

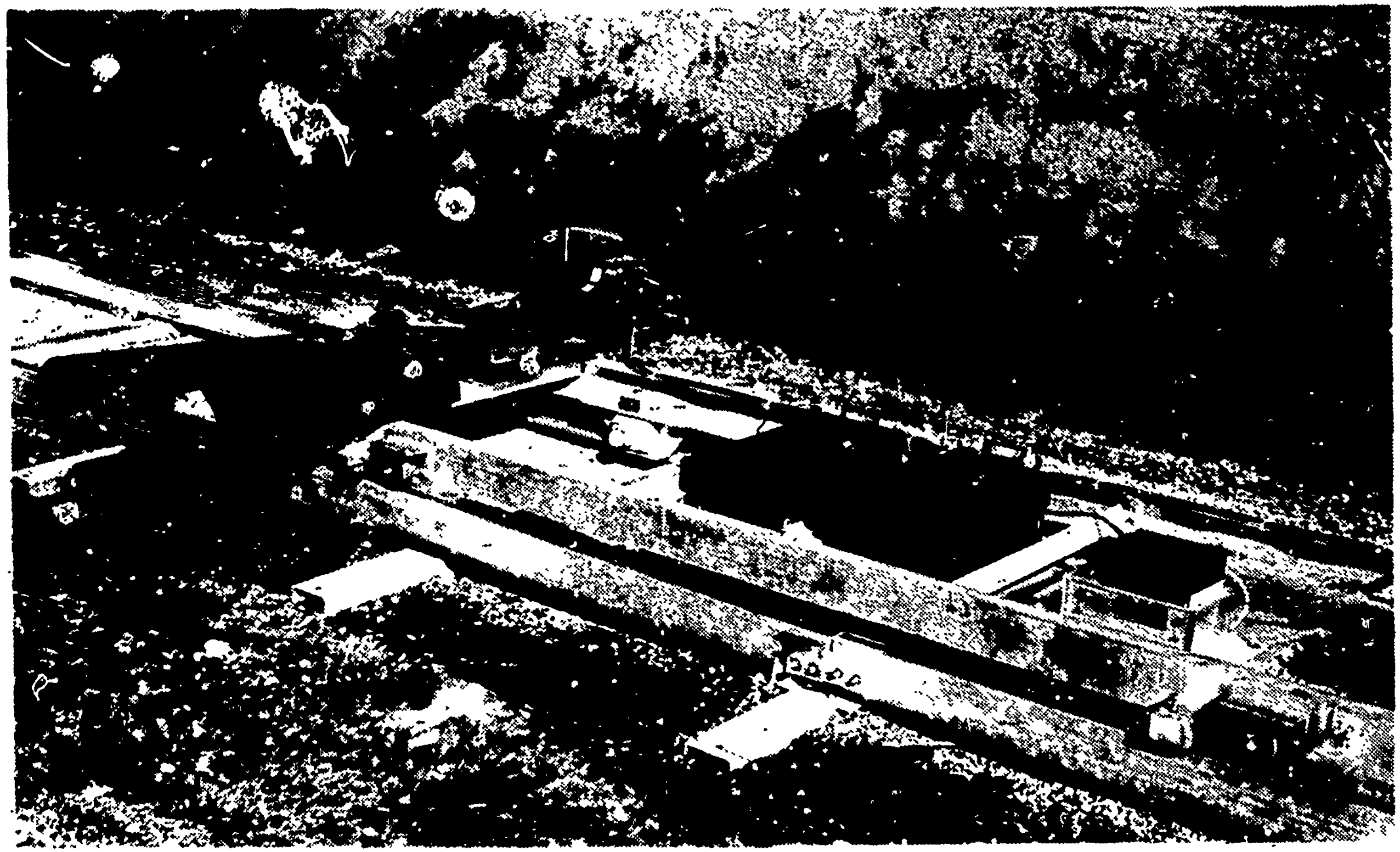


FIGURE 15. View of Target in Lowered Position

take up reels. In operation, cables from both reels payed out through pulleys and were attached to opposite ends of the cart. Depending on the desired cart direction, one of the reels was clutched to the output drive-shaft and the other was allowed to "freewheel." The power system itself was located in a bunker approximately 200 yds. from the track.

An operator, monitoring the tachometer and the speedometer as well as the cart position display panel, was able to move the target cart between designated positions on the track at 6 mph. The cart position display panel consisted of a row of indicator lights corresponding to magnetic switches mounted at 25 ft. intervals on the track. Movement over a switch by the cart caused an indicator light to flash "on." This enabled the operator to know the precise location of the cart as it moved down the track. Figure 16 depicts the polydrive operation.

A radio frequency transmitter-receiver package provided remote control target operation. By monitoring the position display panel and using a stopwatch, the target control operator raised and lowered the target at designated positions on the track. He commanded the target "up" for a period of 2.5 secs. If the target had been hit during this exposure, it automatically killed (went down) due to the operation of the target's sensor mechanism. Figure 17 shows the target control operation.

The moving target system was operated almost continuously for 6 hrs. on each of the two test days. The system's operators and standby maintenance and supervisory personnel were provided from CDCEC's Instrumentation Division. It should be pointed out that only minor problems were encountered during the testing although the cart made about 700 "passes" during this period.

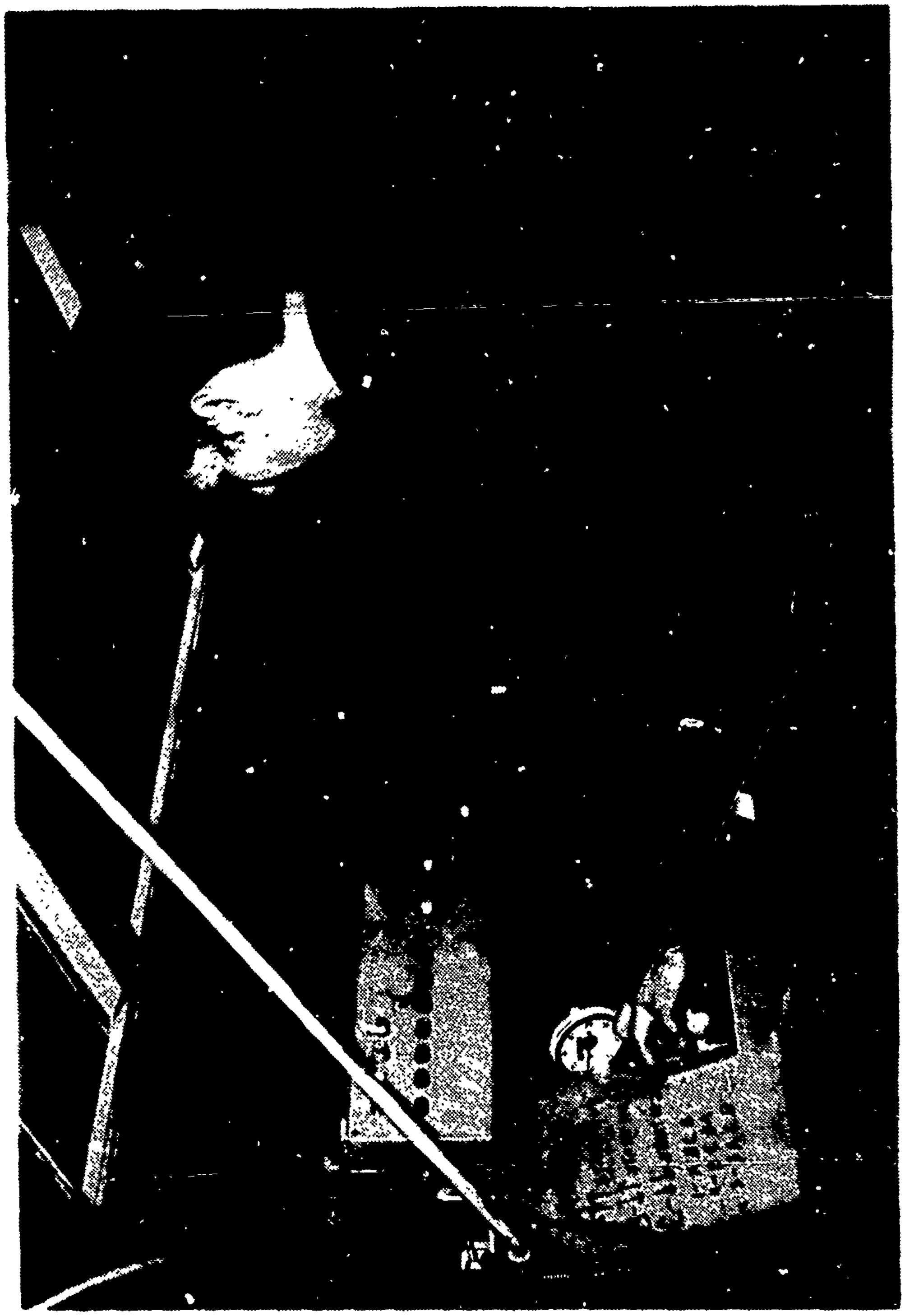


FIGURE 16. View of Polydrive Control Panel and Operator

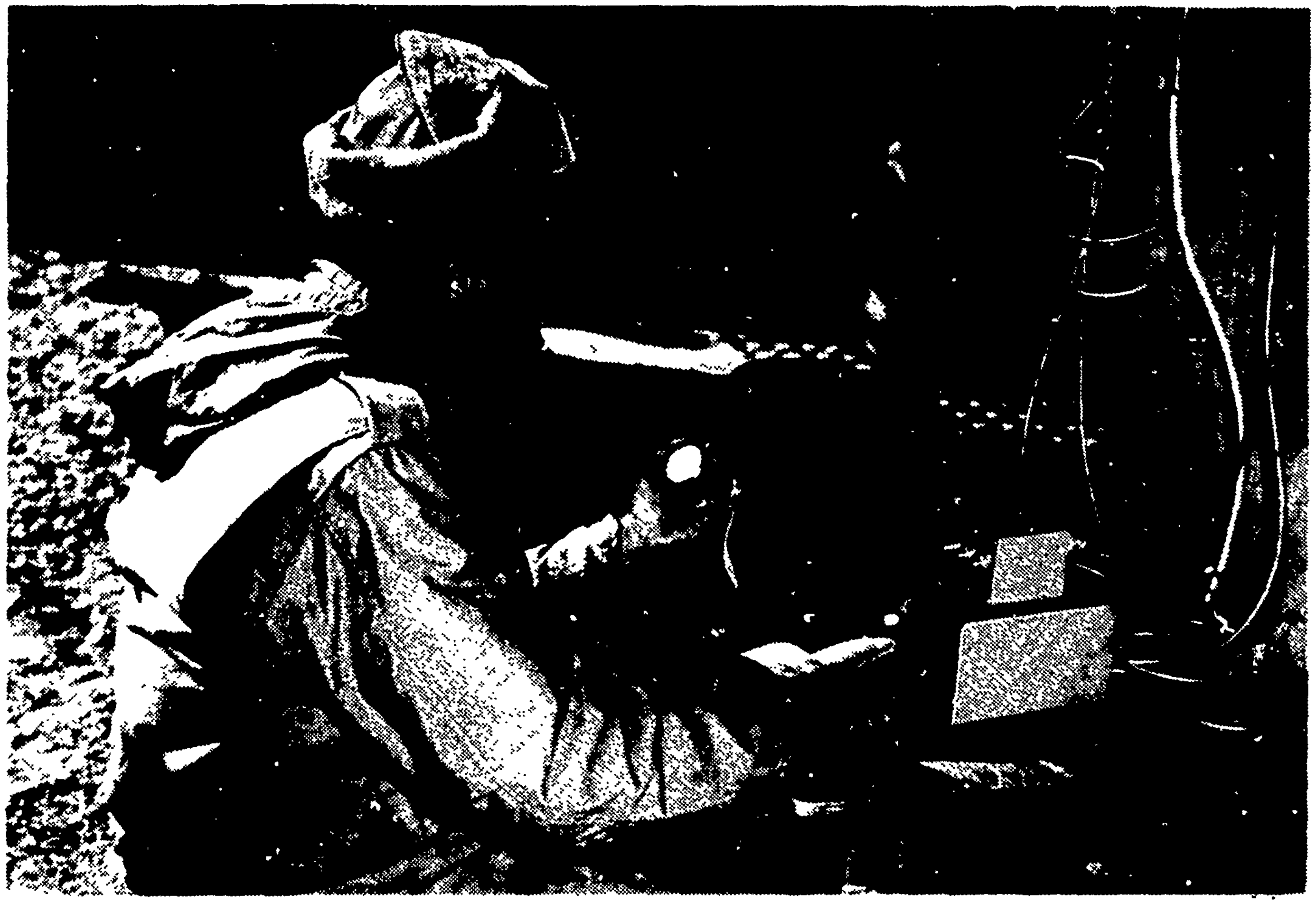


FIGURE 17. Remote Control Transmitter and Target Control Operator

B. TEST PROCEDURE

1. Experimental Design

a. Test Variables

The test variables selected were sight configuration, range to target, and direction of movement of the target. The small circle, large circle, and standard quick-fire using the unmodified M16A1 rifle were chosen as the sight configurations. Experiments had been conducted against stationary targets using these same configurations and the purpose of this follow-on test was to compare those results to results of tests using moving targets. For such a comparison to be valid, the same sight configurations were necessary for both tests.

Since it was desirable to ascertain whether any significance in sight differences were consistent over changes in range and direction, several ranges and directions of target movement had to be tested. Ranges of 25 and 50 yds. were selected because these two ranges effectively exhausted the area where standard quick-fire techniques were effective and because they aided comparison of results with the prior tests against stationary targets. Left and right directions perpendicular to the firer were chosen to provide maximum target exposure area and to duplicate conditions of prior experiments for comparison purposes.

b. Test Design

It was originally conceived that a subject's exposure to each sight-range-direction configuration should be completely random. Under such a configuration a firer would be unaware of the range to target (25 or 50 yds.) or the direction of its movement (left or right of a center point) until he actually observed the target upon activation. This should be the soundest method of conducting such a test if range facilities

will permit. The lack of a parallel track network, range fan constraints, moving target mechanism capability, and a time constraint due to range availability forced several changes in the original test design.

The final test design is depicted in Figure 18. The target mechanism would start at the left end of the track. It would proceed down the track moving left to right at 6 mph. At the left activation point the target would become visible and would be engaged by the subject at firing point No. 1. If hit, the target would "kill"; if not, it would go down after 2.5 secs. The cart would proceed to the right end of the track and turn around. It would then return moving right to left at 6 mph. At the right activation point the target would become visible, be engaged by the subject at firing point No. 2, and then return to the left end of the track. The same procedure would be followed for engagements from 50 yds. Only one round would be fired during each target exposure. A total of 240 rounds were fired for tests with each sight configuration.

Subjects were randomly assigned to begin at left or right firing point. Although randomly assigned, once his firing point was known the firer also knew the direction of movement of the target. This procedure was necessary because the target-cart mechanism required time to gain a constant speed and thus did not have the capability of beginning from a center point and moving left or right at a relatively constant speed. The noise of the moving mechanism would have destroyed any advantage of using another center point activation procedure. The time constraint also dictated the necessity of getting two engagements per round trip of the mechanism, thus the need for a left and right firing point. The order in which each firer engaged the target from each firing point was randomized as was the order in which he would use the three sight configurations.

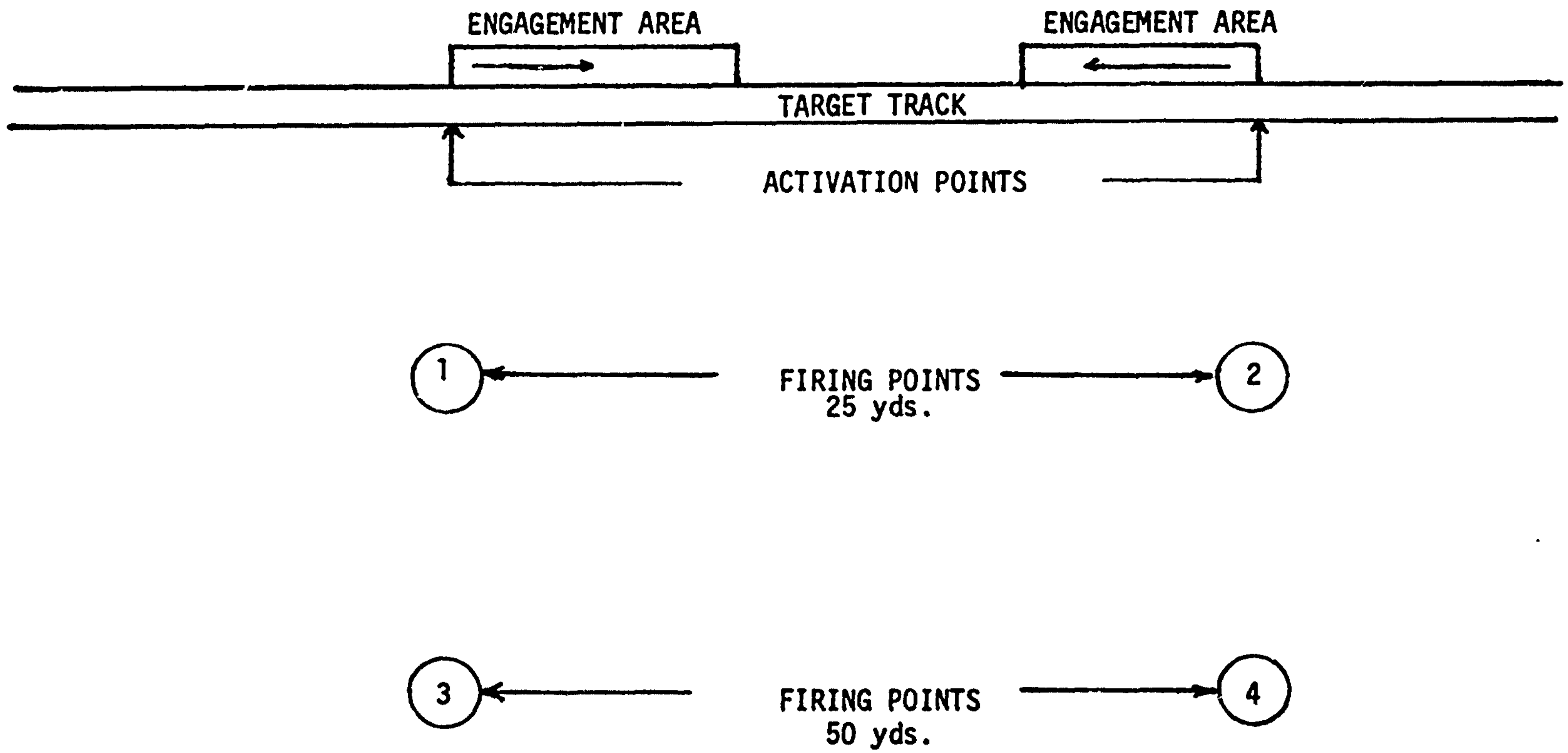


FIGURE 18. Test Design

The absence of a parallel track network 25 yds. apart and the time which would have been required to shuttle firers between ranges made it necessary that the range parameters be fixed. Therefore, all firing was done at the 25-yard range first and then at the 50-yard range.

The data was collected manually from the firing line by a scorer using a prepared data sheet (Figure 19). A hit was scored if the subject fired and the target automatically "killed" prior to the end of the 2.5 sec. exposure time; otherwise, a miss was recorded. Each subject fired 5 rounds with each sight-range-direction configuration.

A post-test questionnaire (Figure 20) was administered to all subjects to obtain their sight preferences, their impressions of the experiment, and information regarding their general background. A summary of the results is included in Table X.

c. Measure of Effectiveness

The experimental test criterion or measure of effectiveness for this experiment was designated as the number of hits scored by each subject for a sight, distance, and direction combination.

d. Target Speed and Exposure Time

The experiment was conducted using a moving target speed of 6 mph and a target exposure time of 2.5 secs. Although it appeared that a realistic need existed to test acquisition processes where the target moved at speeds of 10 to 15 mph and where target exposure time was shorter than 2.5 secs., several factors caused the speed and exposure time to be chosen as they were. Coordination for use of the range facilities and an exploratory firing phase indicated some important experimental constraints:

1) The probability of achieving a useful proportion of target hits using standard quick-fire at target speeds of 10 to 12 mph was exceedingly low.

Data Collection Sheet

1. Subject Number: 1 2 3 4 5 6 7 8 9 10

2. Firing Position: Left Right

3. Target Distance: 25 yds. 50 yds.

4. Target Speed: 6 mph 12 mph

5. Type Sight: Large 0 Small 0 Standard

6.

Target No.	1	2	3	4	5
Hit					
Miss					

7. Mode: Fam Test

FIGURE 19. Sample Data Sheet

QUESTIONNAIRE ON MOVING TARGET EXPERIMENT

This questionnaire is designed to obtain information about each person performing in the moving target experiment. Some questions are specific and should be answered as accurately as possible. Other questions ask for the personal views of the firer on aspects of the experiment.

In filling out the questionnaire, try to be accurate and express YOUR views as best you can. There are no "right" answers. Each person's views are equally important. Take your time and write or print clearly in the spaces provided. If some questions don't apply, put an N/A in the blank space.

1. NAME ____________________

2. RANK ____________________

3. Your subject number for the experiment was ____________

4. Unit assigned to at CDCEC ____________________

5. MOS: Number and title ____________________

6. AGE at last birthday ______ HEIGHT ______ WEIGHT ______

7. Number of years on active duty ________

8. Are you right handed ___ or left handed ___ ? GLASSES? ___YES___NO

9. Have you had any previous Quick Fire Training? ____NO____YES
If YES, state the place, approximate date and type (For example: Ft. Benning, Summer 1968, BCT Orientation) ____________________

____

10. Have you been stationed in Vietnam? ____NO ____YES
If YES, complete the following:
Dates of assignment ____________________
Unit assigned to ____________________
General area of Vietnam ______________ Type terrain ______
Length of tour ____________________
Principal duty performed there ____________________
Did you ever use Quick Fire Techniques in combat?___NO___SOME___OFTEN
If so, were the targets (enemy) ___Stationary___Moving___UNSEEN
______________OTHER

FIGURE 20. Sample Post Test Questionnaire

11. Do you have or have you ever had a physical profile? ____NO____YES
If YES, please describe: (Example, no physical profile until assigned to Vietnam; shot in left arm there, making raising of left arm and hand now very difficult)________________________________
____
____

12. Have you had any special weapons training? ____NO____YES If YES, please describe briefly: (Example, M60 machine gun expert, qualification, Ft. Ord, 1970) ________________________________
____
____

13. How do you feel about firing weapons either militarily or as a sport in civilian life?
- _____ Dislike all firing
- _____ Dislike military firing but like to shoot or hunt off duty or in civilian life
- _____ Don't care one way or the other
- _____ Like military firing but don't shoot or hunt off duty or in civilian life
- _____ Like to fire both militarily and off duty or in civilian life
- _____ Other ________________________________

14. Non-military shooting experience : Member of NRA? _____NO _____YES
a. Have you hunted?
____ Never _____ Once or twice ____ 3-5 times ____ 6-10 times
____ Over ten times
b. If you hunt, is your weapon:
____ Shotgun only ____ Some rifle, mostly shotgun
____ Rifle only ____ Other ____________________
____ Some shotgun, mostly rifle

15. Do you own a weapon? _____NO _____YES If YES, what is it and what is its main purpose? (Example: A 45 cal pistol for protection; a 30.06 deer rifle for hunting) ________________________________
____

16. Would you say the community in which you were raised is
_______ URBAN or ______ RURAL?

17. Comments on the moving target experiment:
a. Do you feel there is a need to improve Quick Fire shooting techniques?
_____ NO _____ YES Briefly tell why: ____________________
____
____

b. Do you feel the idea of bracketing targets with the special sights is a legitimate or valid concept? _____ NO _____ YES Explain your answer: ________________________________
____
____

c. Do you think the way the test was run will help tell which <u>sight</u> is best? _____ NO _____ YES Explain: ____________________

____

____

d. Was the target exposure time:
_____ Too short
_____ Too long
_____ Adequate
_____ Too short for 12 mph speed but okay for 6 mph
_____ Other (Explain) ____________________

____

e. Was target distance:
_____ Too long
_____ Too short
_____ Adequate
_____ Too long for Quick Fire at 50 yds., otherwise okay.
_____ Other (Explain) ____________________

____

f. Was the orientation prior to the experiment helpful in understanding what the experiment was all about? _____ NO _____ YES
COMMENTS: ____________________

____

g. Was the familiarization firing helpful in your performance?
_____ NO _____ YES EXPLAIN (Example, I needed more shots to get used to the moving target) ____________________

____

____

h. Was any part of the firing particularly difficult for you?
_____ NO _____ YES EXPLAIN: ____________________

____

____

i. Which part of the experiment were you most confident in performing?
Mark one block in each column:

____ 6 mph	____ 25 yd	____ right	____ large 0
____ 12 mph	____ 50 yd	____ left	____ small 0
			____ standard

Example:

X 6 mph	X 25 yd	X right	X large 0

j. Would more practice be helpful? ____ NO ____ YES If YES, which part? ____________________

____

k. How could the experiment be improved? ____________________

____

____

l. Which particular sight did you feel you scored better with?

____

m. Do you feel you would have scored much better with a particular sight if exposure time was longer? _____ NO _____ YES
If YES, which sight or sights were these? ________________

____

n. Rank the three sights in order of your preference :
_____________ large circle
_____________ small circle
_____________ standard

PLEASE LOOK OVER EACH QUESTION TO INSURE YOU HAVE ANSWERED <u>ALL</u> OF THEM.

<u>THANK YOU FOR YOUR HELP IN PERFORMING THIS EXPERIMENT!</u>

2) Decreasing target exposure time below 2.5 secs. resulted in a firer's tendency to discard a specific "assigned" technique and to fire carelessly in any manner to achieve a hit.

3) The probability of a major range system failure (broken cables, polydrive breakdown, etc.) was much higher at speeds of 10-12 mph than at the slower 6 mph figure.

4) The availability of the range facilities to include operators was limited due to tests already in progress.

Exploratory firing was keyed to achieve a useful number of hits in an experiment with a high probability of successful completion under the imposed range facility constraints. Exploratory firing confirmed that approximately 30% hits could be attained using the unmodified sights at a speed of 6 mph. This left sufficient room for the other sights to show an increase or decrease in effectiveness. It was also found that exposure times longer than 2.5 secs. did not increase the percentage of hits achieved. The subjects' ability to acquire and track the target proved more critical than time once the 2.5 sec. level was reached. Thus, the values of 6 mph and 2.5 secs. were selected as target speed and exposure time.

2. Conduct of the Experiment

a. Environmental Conditions

The experiment was conducted at Hunter-Liggett Military Reservation, Jolon, California, on 4, 5, and 6 January 1972. The terrain in the immediate area of the test was flat with background hills. There were sparse trees and no brush. The specific firing range employed was level but since the target track was cut into the side of a hill, the firers were at approximately a two-foot lower elevation than the targets.

Such sparse vegetation as was present was not a factor in acquisition or firing. The track and target mechanism were protected by a four-foot high dirt berm. Firers engaged the targets as they appeared above the beam. Due to the height of the berm and the difference in elevation, the lower 30% of the silhouette target was not visible to the firers at both ranges.

The weather on all testing days was clear and sunny with an average temperature of 50-56 degrees and a negligible wind. All familiarization firing was done in the morning when the sun was at the firer's back and all the test firing was done in the early afternoon when the sun was overhead or slightly forward of the firer. The sun was not in a position to deter acquisition.

b. Orientation

Upon arrival at the range the subjects were given an orientation. This orientation consisted of some background information, an explanation of the problem, and a range orientation to include the procedure they would be following during the test. They were given an explanation and weapons demonstration on the techniques they would use for standard quick-fire and for use of the modified sight configurations. A safety briefing was given to establish practices to be used on the firing line. A copy of the orientation is included in Appendix A.

The subjects were then allowed to fire 5 rounds at a stationary target from the 25 yd. range using quick-fire techniques to refresh their memory on firing procedures and to allow the testers to check for satisfactory weapon-body alignment and sighting technique. The target was then allowed to move at 6 mph and each subject was allowed to fire 10 rounds at the 25 yd. range. This permitted the firer to practice the correct firing

techniques against a moving target. It was found that it took the average firer about 10 rounds of practice at a moving target before he could begin to engage it successfully using standard quick-fire.

c. Familiarization Firing

Upon completion of the orientation, the subjects fired a familiarization sequence which was designed to absorb as much of the learning effect as possible before the actual test began. It was originally planned to fire a duplicate of the test sequence (with different random orders) for familiarization but the time constraint made this impossible. It was decided to fire a modified familiarization program which would be comprised of exactly half of a test sequence with the random orders changed. Half the firers would fire all sight configurations from the left firing point at 25 yds. and from the right firing point at 50 yds. The other half would fire the right firing point at 25 yds. and the left firing point at 50 yds. This procedure was adopted to insure that each firer was allowed to fire familiarization at each range and at each direction of target motion. A copy of the firing tables for the familiarization firing is included in Appendix B. Familiarization and test data confirmed that there was no difference in the percentage of hits (52%) between the familiarization and test firing.

d. Test Firing

Upon completion of the familiarization firing, a short break was taken and then the test firing was begun. When the firer's number and his assigned sight configuration were announced, he went to the firing line and secured the appropriate weapon. Upon command he loaded a 20-round magazine, put his weapon in the semiautomatic mode, and observed downrange for the appearance of his target. When the target

appeared, he fired one round at it and was told by the scorer whether he was credited with a hit or a miss. After a short but nonconstant amount of time the target reappeared in the engagement area and the subject engaged the target with one more round. Upon the completion of five engagements the subject cleared his weapon, moved behind the firing line, reloaded his magazine, and awaited his next assignment. During the test firing all subjects fired all sight configurations at each combination of range and direction of target movement. A copy of the firing tables for the test firing is included in Appendix C.

C. ANALYSIS OF DATA

1. Sights

The results of the analysis of variance showed a significant difference in sight configuration effectiveness (Table VIII). Both the small and large circular sight modifications yielded significantly more hits than the unmodified configuration. With a total of 240 rounds fired using each sight configuration the unmodified rifle achieved 25.4% effectiveness in target hits while the small sight achieved 63.3% hits and the large sight had 65.8% hits. This amounts to a 149% increase in effectiveness using the small circular sight as opposed to the unmodified rifle and a 159% increase using the large circular sight (Table III). Application of the Scheffee multiple comparison test for the three sight configurations verified the significant advantage in performance of both the large and small circles over the unmodified sight. It also showed that the difference in performance between the large and small sight is not significant at the 95% confidence level (Table IX).

The data indicated that the circular bracketing sights tested are far more superior to the standard quick-fire method when the target

is moving than when it is stationary. Testing showed that a moving target is extremely hard to successfully engage using standard quick-fire. It is suspected that an increased speed (above the 6 mph tested) would drastically increase the advantage the circular bracketing sights showed over the unmodified procedure with the exact effect depending on the size of the circular sight.

It is significant to note that the tests of these sights against stationary targets [3] showed a 23% advantage for the small circular sight compared to the unmodified and no advantage to the large circular sight. Once the target was set in motion the advantage to the large circular sight not only became significant but was equal to or larger than that for the small sight.

2. Range

The analysis of variance showed that a significantly larger proportion of hits were scored at the 25 yd. range than at the 50 yd. range (Table VIII). The 25-yard targets were hit by 67.7% of the rounds fired while those at 50 yds. were hit 36.4% (Table III). Further analysis showed that the small and large circular sights were approximately 100% (115% and 118% respectively) better at 25 yds. than standard quick-fire and that the improvement is compounded to approximately 250% (244% and 275% repectively) at the 50 yd. range (Table IV). In fact the data revealed that the circular sights were more effective at 50 yds. against a moving target than standard quick-fire was at 25 yds. (Figure 21C).

These results suggested that the inverse relationship between range and accuracy becomes critical at relatively short ranges for moving targets and that the impact of an increased range might be more severe on standard quick-fire techniques than on the circular bracketing type sight.

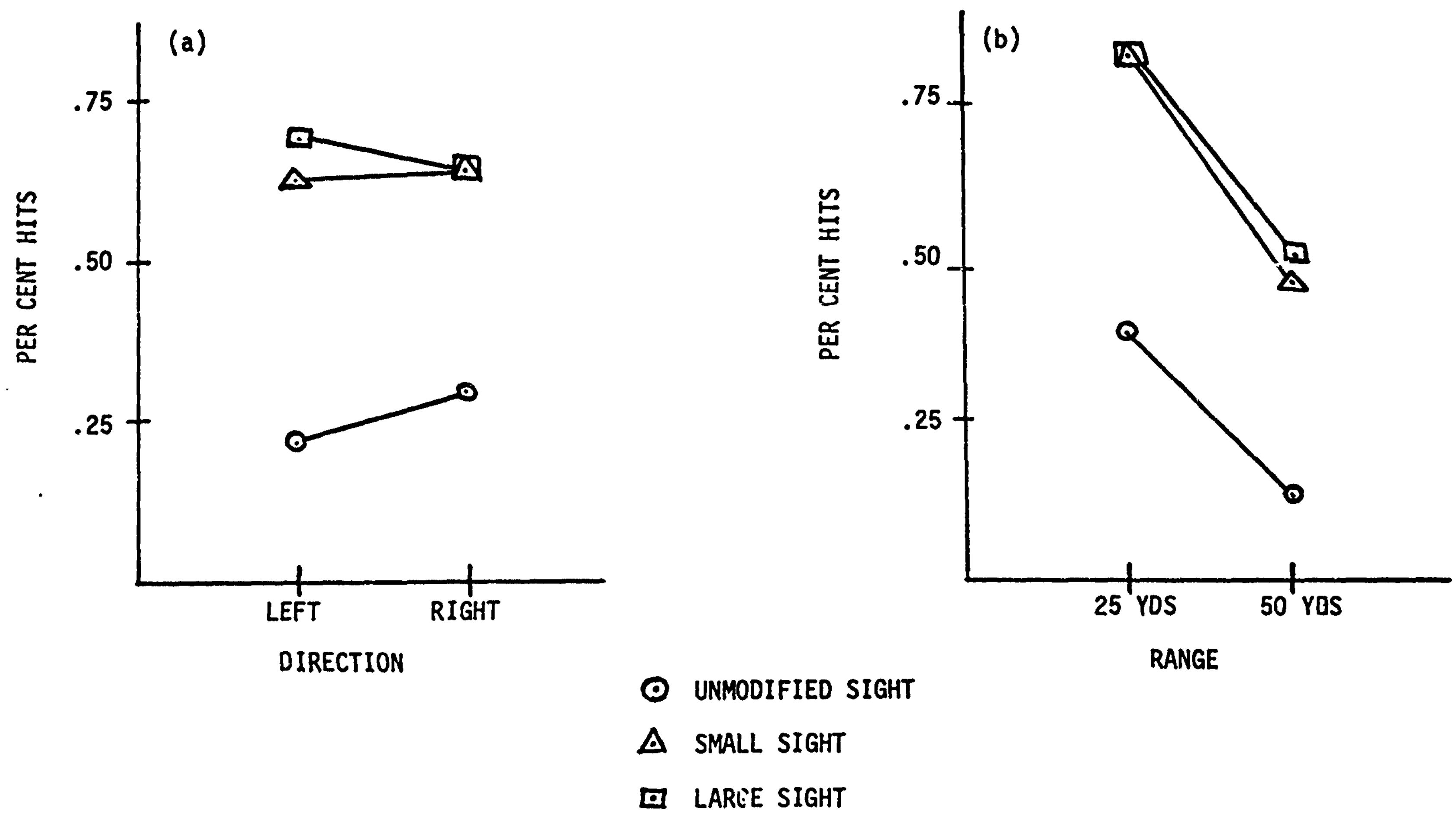
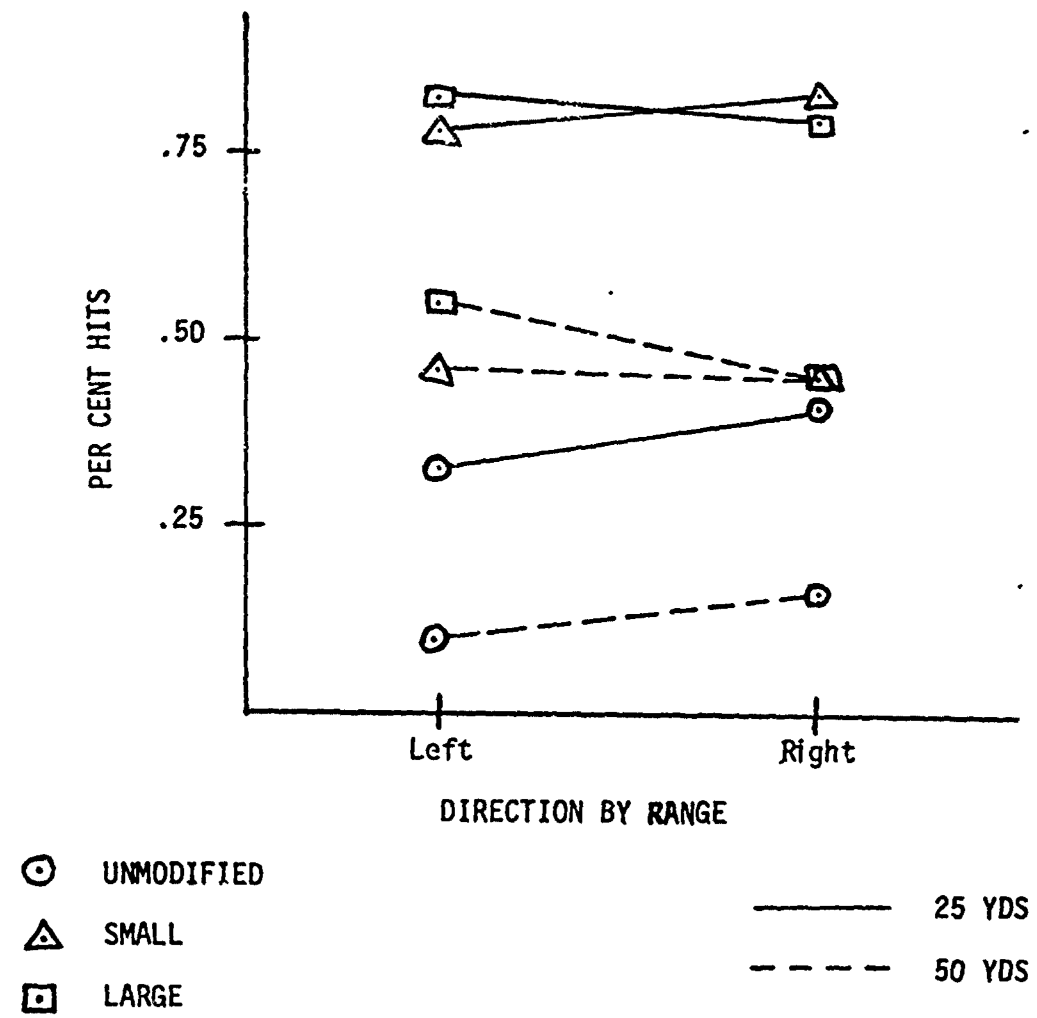


FIGURE 21. Graphical Representation of Relationship Between Range, Direction, Sight Configuration, and Percentage Hits



.75
.50
.25
PER CENT HITS
Left
Right
DIRECTION BY RANGE
UNMODIFIED
SMALL
LARGE
25 YDS
50 YDS

FIGURE 21 (c)

The fact that the subjects were tested at 25 yds. first and then tested at 50 yds. meant that several variables were included in the range effect which was found to be significant. One might have expected some learning effect due to the previous 25 yd. firing; this would have tended to give more hits at 50 yds. than might otherwise have been expected. One might also have expected a fatigue effect due to the previous 25 yd. firing; this would have tended to decrease the number of hits normally expected at the 50 yd. range. Both effects were felt to be minimal due to the frequent breaks in firing for each subject and due to the constant percentage of hits achieved from familiarization through test firing. It was further felt that whatever residual effects of these two variables remained would tend to cancel each other leaving only the normal range effect, as measured.

3. Direction of Movement

There was no significant difference found in the number of hits achieved by a subject engaging a target moving from left to right as opposed to a target moving from right to left (Table VIII). The 12 right-handed firers scored 51.1% hits on left-to-right moving targets and 52% hits on right-to-left moving targets (Table III).

It is interesting to note that in the familiarization firing a right handed firer did tend to have more success tracking a target moving right than left. Familiarization data showed an increase in efficiency of 33% hits on targets which were moving to the right and thus required a left-to-right arm and weapon movement. The absence of this effect during the test suggests that learning effects might equalize a firer's capability to track left or right. The fact that the subjects knew in

advance which direction their target would be moving was not considered significant since the purpose was to measure their ability to track left or right.

4. Interactions

Results of the analysis of variance showed that none of the pairwise interactions were significant and that the three-way interaction was likewise not significant (Table VIII). This indicated that the increase in hits achieved with the two modified sights was consistent over both ranges and both directions of movement tested.

5. Analysis of Variance

The analysis of variance model was a four-factorial, randomized block design. Since the data were of three treatments by subject form and all subjects received all combinations of test variables, the subjects were considered blocks. The actual analysis of variance calculations were performed using the U.S. Naval Postgraduate School's IBM 360 computer system's library program BMD02V [1].

The analysis of variance model was composed of 144 cells. The entry for each cell was the number of hits the subject achieved in 5 shots with the particular sight-direction-range configuration (Table V). The use of analysis of variance techniques required data which was normally distributed. Since the number of observations for each cell was small, an arcsine transformation was used to ensure that the cell entries met the criteria of being normal variates (Table VI). The number of hits per cell were transformed as follows:

$$Z_{ijkm} = 2 \text{ arcsine} \sqrt{X_{ijkm}/5}$$

where Z_{ijkm} = transformed normal variate

X_{ijkm} = original no. of hits in cell i,j,k for subject m

A test using the arcsine statistic is more nearly normal than just using the proportion $X_{ijkm}/5$. Additionally, homogeneity of variance cannot be assumed when using proportional variates. However, if all proportions are based on the same number of observations and if each is transformed to an angle (as the arcsine transformation), the homogeneity of variance assumption is valid because each angle has the same variance 1/N, even though the proportions may differ [5].

The null hypotheses tested were that there was no main effect for each variable and that there were no interactions. These were tested against alternate hypotheses that there were main effects and interactions. In each case an F-ratio test was used with an alpha level of .05 (Table VIII). The only two null hypotheses which could be rejected were the hypotheses that there were no sight effects (no difference between sight configurations) and no range effects (no difference between ranges).

Due to the fact that there were three levels of sight configuration it was impossible to determine between which levels the significance existed based on the original analysis of variance. To make this determination the Scheffe method of multiple comparisons was used [4]. For an alpha level of .05 the large circle vs. unmodified and small circle vs. unmodified showed significant differences while the large circle vs. small circle produced values for which no significant difference could be claimed (Table IX).

6. Questionnaire Results

The questionnaire given to each subject at the conclusion of the test firing was designed to provide an overall subject profile by linking physical characteristics, military personnel data, attitudes toward firing, and the preferences for the three sight configurations. It was hoped

TABLE V TABLE OF OBSERVED DATA

DISTANCE	25 yds						50 yds					
DIRECTION	Left			Right			Left			Right		
SIGHT	U	S	L	U	S	L	U	S	L	U	S	L
SUBJECTS 1	2	3	3	0	5	3	0	4	2	1	0	1
2	1	4	5	0	1	1	0	1	2	0	1	2
3	0	4	5	3	5	4	0	5	4	2	4	5
4	0	1	5	0	5	4	0	2	2	0	4	2
5	4	3	5	2	5	5	1	2	3	0	4	5
6	1	5	3	3	5	5	1	3	4	4	3	1
7	2	4	4	3	5	5	0	2	2	2	2	2
8	1	4	4	0	2	2	2	1	1	0	1	1
9	3	5	5	4	5	5	1	3	5	0	5	3
10	0	4	3	3	4	5	0	1	3	1	0	0
11	2	5	4	4	4	5	1	1	1	0	0	1
12	4	5	4	3	4	4	0	3	4	0	3	4

U = unmodified M16A1

S = small circular sight

L = large circular sight

Note: block entry is number of hits of the 5 rounds fired.

TABLE VI TABLE OF NORMALIZED DATA

SIGHT (i)		unmodified (1)			
DISTANCE (j)		25 yds(1)		50 yds(2)	
DIRECTION (k)		Left(1)	Right (2)	Left(1)	Right (2)
SUBJECTS (m)	1	1.3694	.0	.0	.9273
	2	.9273	.0	.0	.0
	3	.0	1.7722	.0	1.3694
	4	.0	.0	.0	.0
	5	2.2143	1.3694	.9273	.0
	6	.9273	1.7722	.9273	2.2143
	7	1.3694	1.7722	.0	1.3694
	8	.9273	.0	1.3694	.0
	9	1.7722	2.2143	.9273	.0
	10	.0	1.7722	.0	.9273
	11	1.3694	2.2143	.9273	.0
	12	2.2143	1.7722	.0	.0

TABLE VI TABLE OF NORMALIZED DATA (Cont'd)

SIGHT (i)		small(2)			
DISTANCE (j)		25 yds		50 yds	
DIRECTION (k)		Left(1)	Right(2)	Left(1)	Right(2)
SUBJECT(m)	1	1.7722	3.1416	2.2143	.0
	2	2.2143	.9273	.9273	.9273
	3	2.2143	3.1416	3.1416	2.2143
	4	.9273	3.1416	1.3694	2.2143
	5	1.7722	3.1416	1.3694	2.2143
	6	3.1416	3.1416	1.7722	1.7722
	7	2.2143	3.1416	1.3694	1.3694
	8	2.2143	1.3694	.9273	.9273
	9	3.1416	3.1416	.9273	.9273
	10	2.2143	2.2143	.9273	.0
	11	3.1416	2.2143	.9273	.0
	12	3.1416	2.2143	1.7722	1.7722

TABLE VI TABLE OF NORMALIZED DATA (Cont'd)

SIGHT (i)	large(3)			
DISTANCE (j)	25 yds		50 yds	
DIRECTION (k)	Left(1)	Right(2)	Left(1)	Right(2)
SUBJECTS (m) 1	1.7722	1.7722	1.3694	.9273
2	3.1416	.9273	1.3694	1.3694
3	3.1416	2.2143	2.2143	3.1416
4	3.1416	2.2143	1.3694	1.3694
5	3.1416	3.1416	1.7722	3.1416
6	1.7722	3.1416	2.2143	.9273
7	2.2143	3.1416	1.3694	1.3694
8	2.2143	1.3694	.9273	.9273
9	3.1416	3.1416	3.1416	1.7722
10	1.7722	3.1416	1.7722	.0
11	2.2143	3.1416	.9273	.9273
12	2.2143	2.2143	2.2143	2.2143

TABLE VII. ANOVA TABLE OF NORMALIZED DATA FOR 4-WAY FACTORIAL RANDOMIZED BLOCK DESIGN

	VARIABLE	NO. LEVELS	d.f.	SS	MS
(1)	sight configuration	3	2	44.51373	22.25685
(2)	target distance	2	1	25.46517	25.46517
(3)	direction	2	1	.01150	.01150
(4)	subject	12	11	22.95414	2.08674
	INTERACTIONS				
	1 x 2		2	0.69805	0.34903
	1 x 3		2	0.40634	0.20317
	1 x 4		22	8.06567	0.36662
	2 x 3		1	0.32637	0.32637
	2 x 4		11	6.23597	0.56691
	3 x 4		11	6.59290	0.59935
	1 x 2 x 3		2	0.25149	0.12574
	1 x 2 x 4		22	7.39523	0.33615
	1 x 3 x 4		22	11.06510	0.50296
	2 x 3 x 4		11	5.17143	0.47013
	1 x 2 x 3 x 4 (residual)		22	12.08015	0.54910
		TOTAL	143	151.23314	

TABLE VIII. RESULTS OF TEST STATISTICS AND HYPOTHESIS TESTING

TEST		TEST STATISTIC	TEST STAT VALUE	DISTRIBUTION UNDER H_0	$F_d^n(.05)$	RESULT
1	H_0: No effect H_1: Sight effect	$MS_1/MS_{1x2x3x4}$	40.533	F(2,22)	3.44	Reject H_0
2	H_0: No effect H_1: Distance effect	$MS_2/MS_{1x2x3x4}$	46.376	F(1,22)	4.30	Reject H_0
3	H_0: No effect H_1: Direction effect	$MS_3/MS_{1x2x3x4}$	.021	F(1,22)	4.30	Cannot reject H_0
4	H_0: No interaction H_1: Sight x Distance	$MS_{1x2}/MS_{1x2x3x4}$	.636	F(2,22)	3.44	Cannot reject H_0
5	H_0: No interaction H_1: Sight x Direction	$MS_{1x3}/MS_{1x2x3x4}$	.370	F(2,22)	3.44	Cannot reject H_0
6	H_0: No interaction H_1: Dist. x Dir.	$MS_{2x3}/MS_{1x2x3x4}$	.594	F(1,22)	4.30	Cannot reject H_0
7	H_0: No interaction H_1: Sight x Dist. x Dir.	$MS_{1x2x3}/MS_{1x2x3x4}$	.229	F(2,22)	3.44	Cannot reject H_0

TABLE IX. SCHEFFE MULTIPLE COMPARISON TEST (α = .05)

TEST	D	S_D	K	D/S_D	HYPOTHESES	RESULT
Unmodified (1) vs. Small (2)	1.13430	.152	2.48	7.44	H_0: Unmodifies same as small H_1: Small better	Reject H_0
Unmodified vs. Large	1.21989	.152	2.48	8.02	H_0: Unmodified same as large H_1: Large better	Reject H_0
Small vs. Large	.08559	.152	2.48	.562	H_0: Small same as large H_1: Large better	Cannot Reject H_0

$$D = \overline{X}_i - \overline{X}_j$$

$$S_D^2 = S_W^2 \left(\frac{1}{m_i} + \frac{1}{m_j} \right) \quad \text{all } m\text{'s} = 48$$

$$K = (G-1)F_{.95}(G-1, \Sigma m_g - G) \qquad G = 3 \quad \Sigma m_g = 144$$

TEST CRITERION: $D/S_D \geq K \rightarrow$ difference is significant

comparisons to responses obtained in previous research could be made. A complete summary of the questionnaire responses is recorded on a sample questionnaire form (Table X). The data and calculations for Kendall's Coefficient of Concordance are provided in Table XI. This coefficient provides the degree of agreement among the subjects in ranking the sight configurations [2]. Table XII compares these ranks. Deterioration of the effectiveness of the quick-fire technique in a moving target environment was indicated. A high degree of confidence in the small bracketing sight was carried over from a stationary target experiment to a moving target experiment. It should be pointed out that in the stationary target experiment preferences corresponded to hit effectiveness, but in the moving target experiment subjects preferred the small circle although their hit capability with the large circle was about 4% better.

TABLE X

SUMMARY OF QUESTIONNAIRE RESPONSES

1. NAME JOE SOLDIER

2. RANK PFC (E-3)

3. Your subject number for the experiment was 1-12

4. Unit assigned to at CDCEC Co F, 41st Infantry, CDCEC

5. MOS: Number and title 11B Infantryman

6. AGE at last birthday 20 HEIGHT 5'11½" WEIGHT 167.5 lbs

7. Number of years on active duty 1 year

8. Are you right handed X or left handed ___? GLASSES? 8 YES 4 NO

9. Have you had any previous Quick Fire Training? ___ NO 12 YES
If YES, state the place, approximate date and type (For example: Ft. Benning, Summer 1968, BCT Orientation) BCT - 12 subjects, 5 - XM19 Serial Flechette Rifle Experiment, Ft. Ord, California

10. Have you been stationed in Vietnam? 11 NO 1 YES
If YES, complete the following:
Dates of assignment 21 July 70 - 20 Apr 71
Unit assigned to 101st infantry div (airmobile)
General area of Vietnam I & II Corps Type terrain mountainous
Length of tour 9 months
Principal duty performed there infantry pointman
Did you ever use Quick Fire Techniques in combat ___ NO X SOME ___ OFTEN
If so, were the targets (enemy) X Stationary ___ Moving X Unseen
___ OTHER

11. Do you have or have you ever had a physical profile? 11 NO 1 YES
If YES, please describe: (Example, no physical profile until assigned to Vietnam; shot in left arm there, making raising of left arm and hand now very difficult) 1: shot in chest and right lung during Vietnam tour.

12. Have you had any special weapons training? 7 NO 5 YES If YES, please describe briefly: (Example, M60 machine gun expert, qualification, Ft. Ord, 1970) XM19 serial flechette rifle training, Ft. Ord, California

13. How do you feel about firing weapons either militarily or as a sport in civilian life?
  - __2__ Dislike all firing
  - ____ Dislike military firing but like to shoot or hunt off duty or in civilian life
  - __2__ Don't care one way or the other
  - ____ Like military firing but don't shoot or hunt off duty or in civilian life
  - __8__ Like to fire both militarily and off duty or in civilian life
  - ____ Other ________________________________

14. Non-Miltary shooting experience: Member of NRA? __11__ NO __1__ YES
  a. Have you hunted?
  __3__ Never __1__ Once or twice __1__ 3-5 times ____ 6-10 times
  __7__ Over ten times

  b. If you hunt, is your weapon:
  __2__ Shotgun only
  __1__ Rifle only
  __2__ Some shotgun, mostly rifle
  __4__ Some rifle, mostly shotgun
  __3__ Other __no response__

15. Do you own a weapon? __6__ NO __6__ YES If YES, what is it and what is its main purpose? (Example: A 45 cal pistol for protection; a 30.06 deer rifle for hunting) __handguns, rifles, shotguns__
____

16. Would you say the community in which you were raised is
  __8__ URBAN or __4__ RURAL?

17. Comments on the moving target experiment:
  a. Do you feel there is a need to improve Quick Fire shooting techniques? __1__ NO __11__ YES Briefly tell why: ____________
  ____
  ____

  b. Do you feel the idea of bracketing targets with the special sights is a legitimate or valid concept? __1__ NO __11__ YES Explain your answer: ________________________________
  ____

  c. Do you think the way the test was run will help tell which sight is best? __2__ NO __10__ YES Explain: ____________________
  ____

  d. Was the target exposure time:
  - ____ Too short
  - __2__ Too long
  - __10__ Adequate
  - ____ Too short for 12 mph speed but okay for 6 mph
  - ____ Other (Explain) ________________________

f. Was the orientation prior to the experiment helpful in understanding what the experiment was all about? 0 NO 12 YES
COMMENTS: ______

g. Was the familiarization firing helpful in your performance?
0 NO 12 YES EXPLAIN (Example, I needed more shots to get used to the moving target) ______

h. Was any part of the firing particularly difficult for you?
8 NO 4 YES. EXPLAIN: Four complained of the difficulty in hitting the moving target using the standard quick fire method.

i. Which part of the experiment were you most <u>confident</u> in performing? Mark one block in each column:

12 6 mph	11 25 yd	6 right	4 large 0
___ 12 mph	1 50 yd	6 left	8 small 0
			___ standard

j. Would more practice be helpful 5 NO 7 YES If YES, which part? quick fire at both ranges

k. How could the experiment be improved?
more practice with standard quick fire

l. Which particular sight did you feel you scored better with?
unmodified - 0 large - 4 small - 8

m. Do you feel you would have scored much better with a particular sight if exposure time was longer? 10 NO 2 YES If YES, which sight or sights were these? ______

n. Rank the three sights in order of your preference:

RANK	1	2	3	
	3	9	0	large circle
	9	3	0	small circle
	0	0	12	standard

TABLE XI DATA OF SUBJECT SIGHT PREFERENCE AND CALCULATIONS FOR KENDALL'S COEFFICIENT OF CONCORDANCE TEST

SIGHT RANKINGS (1, 2, or 3)

subjects	Standard	Small	Large
1	3	1	2
2	3	1	2
3	3	1	2
4	3	1	2
5	3	1	2
6	3	2	1
7	3	1	2
8	3	1	2
9	3	1	2
10	3	2	1
11	3	2	1
12	3	1	2
R_i	36	15	21

$N = 3$
$K = 12$

$$\sum_{i=1}^{3} R_i = 72$$

$R_i - \dfrac{\Sigma R_i}{N}$	12	-9	-3
$(R_i - \dfrac{\Sigma R_i}{N})^2$	144	81	9

$$S = \sum_{i=1}^{3}(R_i - \frac{\sum_{i=1}^{3} R_i}{N})^2 = 234 \qquad W = \frac{S}{\frac{1}{12} K^2(N^3-N)} = \frac{234}{288} = .81$$

H_0: There is no preference agreement among subjects

$$X_W{}^2 = \frac{12\ K\ S^2_{sum}}{\text{Cols}[K(K+1)]} = 71.8$$

For $\alpha = .05$ $\qquad 71.8 > 4.58$

significant difference Reject H_0

TABLE XII SUBJECT SIGHT PREFERENCES

SIGHT CONFIGURATION	RANKING 1	2	3
unmodified	0*	0	12
small circle	9	3	0
large circle	3	9	0

Subjects preference agreement supported by Kendall's coefficient of concordance, w = .81

* Number of subjects giving number one ranking to the unmodified sight configuration.

APPENDIX A. ORIENTATION

I. INTRODUCTION/WELCOME

Gentlemen, I am Cpt. McLeskey and this is Cpt. Fisher. We appreciate the fact that you are here today and we hope that this experiment will be interesting to you as participants. We feel that the experimental results may be a significant contribution to the work of the Army and other agencies trying to improve the effectiveness of the M16 rifle. Basically we have designed an experiment to test the M16 rifle modified with two sizes of circular bracketing sight as shown here against the standard quick-fire technique. You will be firing at a moving silhouette target at short ranges. We will be interested not only in your hits on the moving target but also in your own personal views as to sighting system preference.

The experiment will consist of firing the M16 rifle with each of the three si t configurations at a moving target from ranges of 25 and 50 yards. The target will be exposed for approximately 2.5 seconds for each trial. We shall now look at the technique of firing that will be used.

II. PRESENTATION OF LECTURE/DEMONSTRATION

There are two methods of fire used in this experiment. The first is the "quick-fire" technique which should be familiar to each of you already. This technique will be used when firing the standard unmodified M16. The second technique is a slight modification of quick fire and it will be used with the sight modified M16's.

For a moment I would like you to recall the quick fire technique and we will review both the technique and the characteristics of this method of fire. Has everyone here had some type of orientation firing using quick fire? Good! You will recall that this technique is often called "instinct shooting." The basis of the technique is to sight on the target with BOTH EYES OPEN, move the rifle instinctively toward the target and fire. There is no compensation for wind or trajectory since the technique is most often used at short ranges. You might recall that your orientation training consisted in firing a rifle with the sights covered and that you first fired an air rifle then moved on to stationary ground targets using the M-16. The basic characteristics of the technique are:

1. Both eyes open at all times and 2" to 3" above barrel line.
2. Rifle is initially at high port arms.
3. Weight is distributed on your feet so that you don't have to shuffle your feet to engage the target.
4. Eyes are focused on the lower part of the target.
5. Rifle is brought up smoothly, a stock weld is obtained keeping eyes and barrel in parallel.

Watch the Demonstrator.

Mention 2 don't's:

1. Don't use the sights.
2. Don't snap the rifle at the target.

Are there any questions on the quick fire technique? This is the first firing technique and it is to be used only when firing the standard M-16.

The second technique to be used when firing the M-16 with either the large or small circular sight is as follows:

1. The rifle is initially in the high port arms position.

2. The weight is distributed on both feet so that shuffling of the feet is not required.

3. The rifle is brought to the shoulder and a stock weld obtained.

4. The left eye is closed and the target is bracketed in the circular front sight using the right eye.

Watch the demonstrator go through these steps!

Any questions on this technique?

III. EXPLANATION OF THE MOVING TARGET RANGE

Now that we have considered the techniques of fire, I would like to explain the range setup and operation for the experiment.

Show diagram of the range. Point out salient physical features.

1. The target on the track system is a silhouette target designed to rise at specific points directly in front of the left and right firing positions.
2. The target will be moving at a slow speed of 6 mph.
3. The target will stay up for 2.5 seconds or 22 feet at 6 mph.
4. If the target is hit while exposed it will go down and a "hit" will be recorded. Otherwise a miss is recorded. You will be told the results of each engagement.

IV. EXPLANATION OF FIRING PROCEDURE

1. Firing positions have been marked at 25 and 50 yds. left and right.
2. You will be assigned a subject number for the day's firing. Remember this number. It will determine your sequence and position for firing at each range.
3. You will be assigned to a firing position at random. Here you will fire a designated familiarization course with the designated M-16 sighting systems.

4. After this familiarization the test firing will proceed in a similar manner but not exactly the same order.

5. You will fire all ranges, directions, and sight configurations according to the test plan and the subject number assigned to you.

V. SAFETY

Prior to any firing it's the responsibility of each one of us to review and keep in mind general as well as specific safety regulations.

1. A cleared weapon is one with the bolt open, and locked to the rear, magazine removed, safety engaged, and chamber void of ammo.
2. After firing all rifles will be checked to insure they are clear.
3. When not being fired a rifle will be cleared.
4. When holding a rifle never point it toward anyone, but keep it up and down range.
5. Ammo will not be loaded except on command.
6. Explain safety limits of the range.
7. When not being used, the rifles will be placed on their racks in a cleared condition.
8. Smoking will not be permitted except during breaks.
9. No running on the range.
10. Do not move forward of the firing line unless instructed by the OIC to do so.
11. If you sight an unsafe condition yell out "Cease Firing." All persons firing will observe this condition.
12. No ammo or brass will leave the range.
13. Listen to the instructions of all range control personnel.
14. If your rifle malfunctions, raise your hand and tell the OIC at your firing position.

VI. SUMMARY/CONCLUSION

1. Are there any questions that you may have concerning any portion or phase of the experiment?

Is there any area of the technique of firing, either quick fire or the modified version that you don't understand or would like to see demonstrated again?

2. I want each of you to always be safety conscious when handling the weapons. Secondly, do the best you can in the firing. We feel that the experimental data and subsequent knowledge gained from your participation will assist others in comparing the effectiveness of different sight modified M-16's in a quick reaction environment. Almost assuredly other experiments will follow, perhaps night firing or perhaps different types of sights. Those subsequent experiments will try to compare their results with what will be done here today. Finally we want you seriously to consider your preferences for the different sights in filling out a questionnaire on the experiment at the end of firing today.

APPENDIX B. FAMILIARIZATION FIRING TABLES

POINT 1

Subject	Sight
1	U L S
5	L U S
6	S U L

POINT 2

Subject	Sight
3	S U L
2	L U S
4	S U L

POINT 3

Subject	Sight
2	L U S
3	U S L
4	L S U

POINT 4

Subject	Sight
5	U L S
6	S L U
1	S L U

Notes: 1. Points 1 & 2 completed first

2. Typical sequence for point 1:

1 - U
5 - L
6 - S
1 - L
5 - U
6 - L
etc.

U = unmodified S = small circle L = large circle

POINT 1

Subject	Sight
9	U S L
12	S L U
8	S U L

POINT 2

10	S U L
11	U L S
7	L U S

POINT 3

7	U L S
11	S U L
10	U L S

POINT 4

12	U L S
8	U S L
9	S L U

APPENDIX C. TEST FIRING TABLES

POINT 1				POINT 2			
order 1		order 2		order 1		order 2	
subject	sight						
1	U S L	3	U S L	5	S L U	6	L S U
6	L U S	2	U L S	3	S U L	4	S L U
4	U S L	5	L U S	2	U L S	1	L S U

POINT 3				POINT 4			
order 1		order 2		order 1		order 2	
1	L S U	6	U S L	6	L U S	1	U L S
5	U S L	[illegible]	L U S	2	S L U	5	S L U
4	S L U	2	S U L	3	U S L	4	L U S

Notes:

1. Points 1 & 2 completed first
   (sequence: order 1 at points 1&2, then order 2 at points 1&2)
   order 1 at points 3&4, then order 2 at points 3&4)

2. Typical sequence for point 1:
   1 - U
   6 - L
   4 - U
   1 - S
   6 - U
   etc.

U = unmodified   S = small circle   L = large circle

POINT 1

order 1 subject	sight	order 2 subject	sight
7	U L S	10	L S U
12	L U S	11	S L U
8	U L S	9	U L S

POINT 2

order 1		order 2	
10	L S U	8	L U S
9	L U S	12	S U L
11	S U L	7	U S L

POINT 3

order 1 subject	sight	order 2 subject	sight
9	L U S	7	S U L
12	U S L	11	U L S
8	U S L	10	L U S

POINT 4

order 1		order 2	
10	U L S	8	U L S
11	U S L	9	S U L
7	S L U	12	U L S

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